109° CONGRESSO NAZIONALE
Società Italiana di Fisica

SIF23 Salerno

Salerno, 11-15 settembre 2023

UNIVERSITÀ DEGLI STUDI
DI SALERNO

Dipartimento di
Fisica E.R. Caianiello

A cura di B. Alzani, M. Bellacosa e G. Bianchi Bazzi
Redazione dei testi a cura dello Staff editoriale della SIF
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Società Italiana di Fisica

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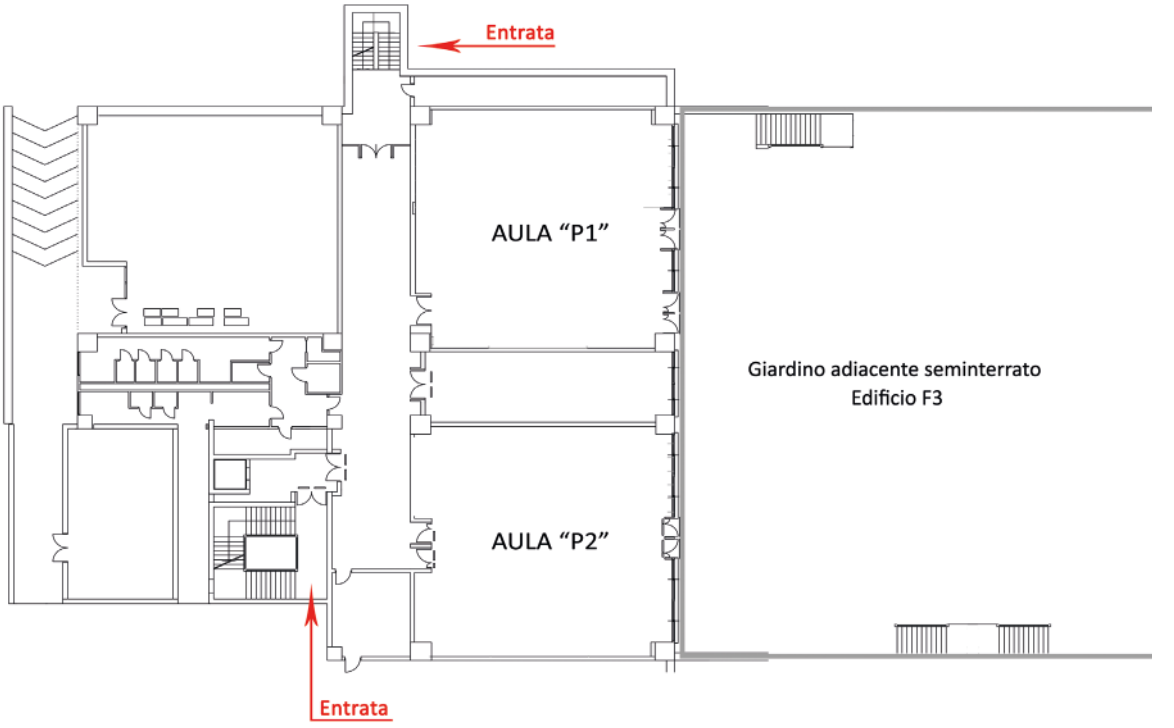

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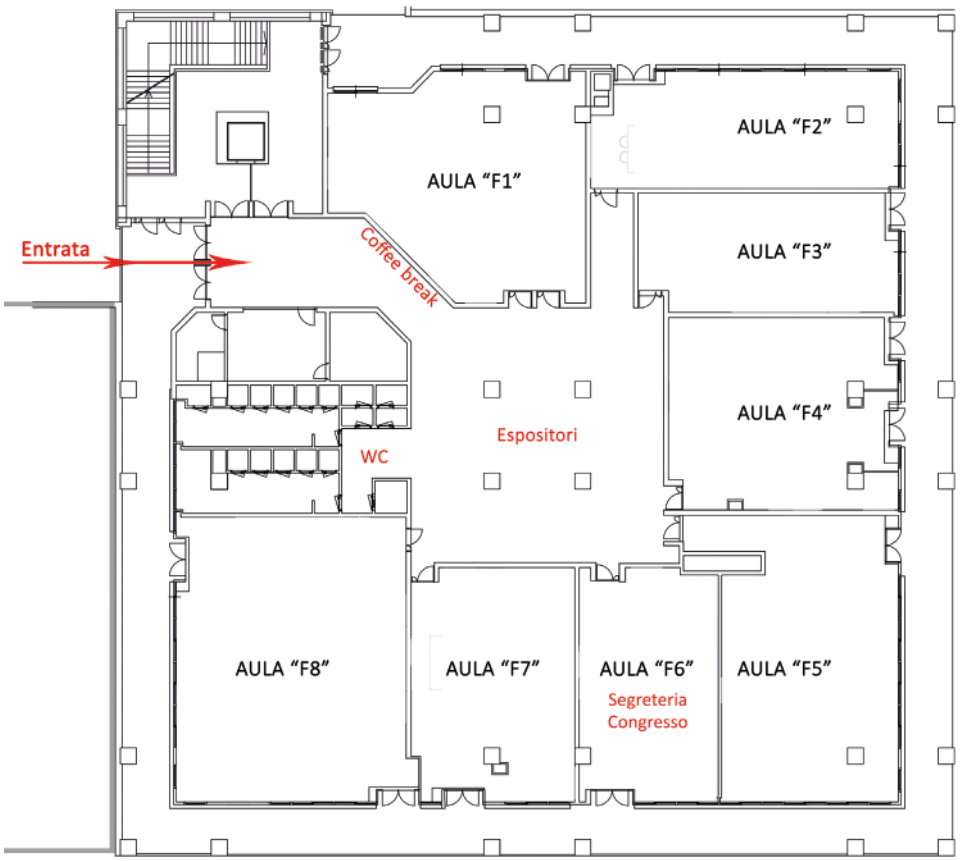

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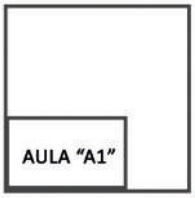

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“VINCENZO
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AULA MAGNA

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Sezione Giovani **In collaborazione con l'Associazione Italiana Studenti di Fisica (AISF) e con il Progetto Young Minds dell'EPS.**

SIMPOSI

Fisica Statistica e Sistemi Complessi
si terrà nell'ambito della Sezione 2 Fisica della Materia

Optometria
si terrà nell'ambito della Sezione 6 Fisica applicata, acceleratori e beni culturali

INFORMAZIONI GENERALI

Sede del Congresso

La cerimonia di inaugurazione si terrà l'11 settembre alle ore 9.00 presso l'Aula Magna del Rettorato "Vincenzo Buonocore" (Edificio A2) dell'Università di Salerno a Fisciano, Via Giovanni Paolo II n 132.
Tutti i lavori del Congresso si svolgeranno presso il Dipartimento di Fisica "E.R. Caianiello" dell'Università di Salerno e in particolare negli Edifici F2 e F3 del Campus di Fisciano.

Iscrizioni

Quote di iscrizione al Congresso per i Soci (*)	
Socio Ordinario	€ 90,00
Socio Junior (under 40)	€ 75,00
Socio Invitato (neolaureato in Fisica)	€ 75,00

(*) Per i Relatori su Invito e i Chair si applica la stessa quota dei Soci Ordinari

Quote di iscrizione al Congresso per i non Soci	
Partecipante Ordinario	€ 160,00
Partecipante Junior (under 40)	€ 135,00

Le iscrizioni devono essere effettuate online entro le ore 12:00 del 4 settembre 2023.
La quota dà diritto alla cartella congressuale contenente il volume degli Atti del Congresso con i riassunti delle relazioni e delle comunicazioni. Per partecipare ai lavori congressuali è necessario essere muniti di targhetta nominativa che attesti la registrazione al Congresso.

Relazioni Generali, Relazioni su Invito e Comunicazioni

Nel programma sono segnalate dai seguenti simboli:

- ■ Relazioni Generali
- ▲ Relazioni su Invito
- ● Comunicazioni

Per la presentazione orale delle relazioni su invito e delle comunicazioni gli autori avranno a disposizione rispettivamente 20 minuti + 5 di discussione per le relazioni su invito e 10 minuti + 2 di discussione per le comunicazioni, compatibilmente con il programma della Sessione. L'autore, il cui nome figura sottolineato, sarà il presentatore della comunicazione. Almeno uno degli autori, possibilmente il presentatore, deve essere Socio della Società Italiana di Fisica.

Migliori comunicazioni

Un'apposita commissione segnalerà al Consiglio di Presidenza della SIF un certo numero di comunicazioni (il 20-30% circa) per ogni sezione giudicate migliori sulla base del contenuto e/o dell'esposizione. Per i presentatori che vinceranno sono previsti premi e/o la pubblicazione degli articoli in un fascicolo speciale de Il Nuovo Cimento, garantendo una pubblicazione on-line in "open access". La premiazione dei relatori avrà luogo durante la cerimonia inaugurale del Congresso Nazionale SIF del 2024.
Esclusivamente gli iscritti al Congresso avranno la possibilit di partecipare alla selezione.

Si ringraziano i seguenti Enti e aziende che, con il loro Patrocinio e il loro contributo finanziario e operativo, hanno reso possibile l'organizzazione del Congresso

Università di Salerno
Dipartimento di Fisica "E.R. Caianiello" Università di Salerno
INFN - Istituto Nazionale di Fisica Nucleare
INGV - Istituto Nazionale di Geofisica e Vulcanologia
INAF - Istituto Nazionale di Astrofisica
GSSI - Gran Sasso Science Institute
INRIM - Istituto Nazionale di Ricerca Metrologica
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CNR-SPIN
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Quantum Machines
Astro Alliance
IPSOEA "R. Virtuoso"
Liceo Statale "Alfano 1" Salerno
TUCANO

Con il Patrocinio del Comune di Salerno

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Aula Magna Rettorato V. Buonocore - Edificio A2 **ore 9:00 – 10:30**

CERIMONIA DI INAUGURAZIONE
INTRODUZIONE DEL PRESIDENTE
Prof. Angela Bracco

PREMIAZIONI:

Premio "Enrico Fermi"

Premio "Giuseppe Occhialini" SIF-IOP (Institute of Physics)

Premio per la Didattica o la Storia della Fisica

Premio per la Comunicazione Scientifica

Premio "Laura Bassi" per le Donne nella Fisica

Premio SIF-SoNS "Neutrons Matter"

Premio SAIt-SIF "Giovanni Bignami"

Premio "Giuliano Preparata"

Premio "Vincenzo Ferraro"

Borsa "Ettore Pancini"

Borsa "Antonio Stanghellini"

Premi per giovani laureati in Fisica dopo il maggio 2016 e dopo il maggio 2020

Premi per le Migliori Comunicazioni al Congresso Nazionale 2022

Soci Benemeriti della SIF

Aula Magna Rettorato V. Buonocore - Edificio A2 **ore 10:30 – 11:10**

Sezione VI
Fisica applicata, acceleratori e beni culturali
Presiedono: Falciano S. (GSSI, L'Aquila)
Ghigo A. (INFN, Laboratori Nazionali di Frascati)

Relazione Generale

Materials, methods and priorities for the development of the hydrogen value chain.
Crema L.
Center for Sustainable Energy, Fondazione Bruno Kessler, Trento, Italy and Hydrogen Europe Research, Brussels, Belgium
Hydrogen is seen as one of the most promising energy carriers to enable the deep decarbonization of our society, contributing to the development of a resilient energy system. Research will be a key driver to develop novel solutions and technologies provided with high performances, lower costs, without critical raw materials: from production, to handling and storage, to end uses. Advanced materials for electrolysis, novel technologies with innovative functionalities, breakthrough solutions will require dedicated support to enable a hydrogen sector in line with the European policies underway. Several key solutions will leverage the conversion efficiency of electrolysis up and beyond 80%, reducing the need for scarce or costly materials such as iridium or other transition metals. Novel solutions can directly produce hydrogen splitting water from direct solar radiation. New proton conductive ceramic cells can add functionalities to hydrogen production such as compression, purification, separation of hydrogen or co-electrolysis processes. Mature technologies can be then improved through novel collaboration schemes between research and industry, enabling a levelized cost of hydrogen compatible with the market needs. This will change the perspective of having a novel, clean, diffuse gas sector in form of 100% hydrogen.

Aula Magna Rettorato V. Buonocore - Edificio A2 ore 11:10 – 11:50

Sezione I
Fisica nucleare e subnucleare
Presiede: Gramegna F. (INFN, Laboratori Nazionali di Legnaro)

Relazione Generale

Challenging moments in nuclear structure.

Leoni S.
University of Milano and INFN, Sezione di Milano

Understanding the structure of atomic nuclei, from the deuteron to the super-heavy elements, is one of the greatest challenges of modern nuclear physics. In a broader context, the knowledge of nuclear structure is a key ingredient to achieve a comprehensive microscopic description not only of nuclear systems, but also of extended nuclear astrophysical phenomena, as well as nuclear reactions and decays. Experimental breakthroughs with high-intensity stable beams and newly available exotic isotopes, novel theoretical concepts, and fast progresses in computer technologies and numerical algorithms, make nuclear structure a modern and lively research field. Exciting prospects span from fundamental physics to a large variety of societal applications, including medicine and energy productions. In this presentation, the impact of high-precision gamma and particle spectroscopy in investigating the structure of atomic nuclei will be discussed, aiming at shedding light on fundamental properties of the strong force. We will focus on the important scientific and technical advances which are presently being made with the development of state-of-the-art spectrometers, as, for example, the European AGATA gamma-tracking array which is currently operational at the Legnaro National Laboratory of INFN.

Aula Magna Rettorato V. Buonocore - Edificio A2 **ore 11:50 – 12:20**

Relazione Generale Speciale in occasione dei 100 anni del CNR

Presiede: Bracco A. (Università di Milano)

Il Consiglio Nazionale delle Ricerche celebra quest'anno i cento anni dalla sua fondazione. La presidente del CNR rievoca una storia prestigiosa, ripercorre il significativo impatto sullo sviluppo scientifico e sulla crescita della nostra società realizzato attraverso le molteplici attività di ricerca, anche nel campo della Fisica, e delinea le sfide e le prospettive che attendono l'Ente negli anni a venire.

Relazione Generale

Il futuro della scienza al CNR.

Carrozza M.C.
Presidente CNR

Il CNR celebra il suo centesimo anniversario in una fase storica percorsa da criticità globali, rispetto alle quali la scienza può e deve offrire risposte concrete, interpretando i bisogni sociali più diffusi nell'ottica di uno Sviluppo Sostenibile del Pianeta. Nel concepire il Presente come età della resilienza, il CNR ha individuato diverse priorità su cui orientare la propria azione, rappresentate dalle seguenti key-words: *patrimonio culturale, scienze della vita, transizione verde, transizione digitale, energia pulita, sostenibilità, biodiversità, economia circolare, pace e diplomazia scientifica, one health.* Sfruttando le opportunità offerte dal PNRR e riconoscendo l'importanza strategica delle Infrastrutture di Ricerca, il CNR sta promuovendo l'internazionalizzazione e la valorizzazione della ricerca italiana, al fine di rafforzarne la capacità attrattiva e di consolidare la *leadership* scientifica del nostro Paese, in un contesto geopolitico in divenire. In tal senso, il CNR ha messo a punto un Piano di Rilancio, dando avvio ad un percorso di riforma con l'obiettivo di migliorare la programmazione, la qualità della ricerca e la capacità di attrarre e trattenere i talenti, contribuendo alla formazione di leader scientifici del futuro. A tale scopo, è in atto una riorganizzazione scientifica, volta alla promozione della libertà della ricerca e dell'interdisciplinarità, la cui struttura si fonda su ambiti disciplinari (ispirati ai panel ERC) e sulla creazione di un nuovo sistema di sostegno a grandi progetti interdisciplinari attraverso strumenti innovativi (ad es. *Goal-Oriented Research Unit*). La Scienza immaginata dal CNR nel suo centesimo anno è, dunque, una ricerca venuta dal futuro, che nelle potenzialità racchiuse nell'innovazione e nella transizione – ecologica, energetica, economica e digitale – trova le soluzioni per le sfide del Presente.

Aula Magna Rettorato V. Buonocore - Edificio A2 **ore 14:00 – 16:00**

TAVOLA ROTONDA

Scienza e tecnologie quantistiche in italia: Prospettive e opportunità

Le tecnologie nate dalla fisica quantistica sono alla base di tutti gli strumenti avanzati che usiamo ogni giorno. Lo sfruttamento nei prodotti industriali di domani delle capacità offerte dai concetti quantistici più avanzati quali la sovrapposizione degli stati o l'entanglement delle particelle rappresenta il cuore della seconda rivoluzione quantistica e delle sue dirompenti possibilità.

Per cogliere questa grande opportunità e mettere a sistema le grandi capacità dei ricercatori e della estesa rete di laboratori nazionali, l'Italia ha inserito la scienza e le tecnologie quantistiche prima nel proprio Piano Nazionale di Ricerca (PNR) e poi nel Piano Nazionale di Ripresa e Resilienza. In linea con quanto previsto nel PNR sono stati avviati il completamento dell'Italian Quantum Backbone per la Comunicazione Quantistica, la creazione di un Centro per la Computazione Quantistica affiancato al calcolo ad alte prestazioni e l'istituzione di un Partenariato Esteso Nazionale per coordinare e sviluppare l'intera catena scientifica e tecnologica del processo d'innovazione, nonché assicurare l'adeguata formazione multidisciplinare. Parallelamente gli scienziati italiani si stanno organizzando in una nuova società scientifica per garantire la partecipazione di tutta la comunità nazionale.

Questa tavola rotonda, promossa all'interno dei lavori del 109° Congresso Nazionale della Società Italiana di Fisica a Salerno, intende mettere a confronto alcuni tra i principali protagonisti, sulle azioni intraprese a livello nazionale e delineare il percorso che si sta definendo per mantenere l'Italia uno dei paesi leader nel campo.

Introduzione:
Angela Bracco (Presidente della Società Italiana di Fisica)
Salvatore De Pasquale (Università di Salerno, Coordinatore PNR)

Moderatori:
Roberta Citro (Università di Salerno)
Francesco Saverio Cataliotti (Istituto Nazionale di Ottica del CNR)

Interventi di:
Maria Chiara Carrozza (Presidente del Consiglio Nazionale delle Ricerche)
Fabio Beltram (Scuola Normale Superiore)
Simone Montangero (Università di Padova)
Gioacchino Massimo Palma (Università di Palermo)
Rosario Fazio (Abdus Salam International Center for Theoretical Physics)
Elisabetta Paladino (Università di Catania)
Natalia Bruno (Consiglio Nazionale delle Ricerche)

Aula F1 - Augusta Manfredini **ore 16:15 – 19:30**

Sezione I
Fisica nucleare e subnucleare
Presiedono: Nania R. (INFN, Sezione di Bologna)
Gramegna F. (INFN, Laboratori Nazionali di Legnaro)

Relazioni su invito

▲ **Hidden and open heavy-flavour measurements with ALICE.**
Fionda F.M.C. per la ALICE Collaboration
University of Cagliari and INFN, Cagliari Division
Heavy-flavour (HF) hadrons, *i.e.*, bound states containing charm or beauty quarks, are excellent probes of the hot and dense medium created in ultra-relativistic heavy-ion collisions, known as quark-gluon plasma. Heavy quarks are produced in the initial hard partonic scatterings, thus they experience the full collision history. Comprehensive measurements of quarkonia and open HF hadrons in Pb-Pb collisions, allow for testing the mechanisms of heavy-quark transport, energy loss, and coalescence effects during the hadronisation in the presence of the hot medium. Corresponding results in small systems, such as pp and p-Pb collisions, represent an important baseline for interpreting Pb-Pb measurements. Besides serving as reference, results in small systems are crucial for testing production mechanisms in the absence of hot medium effects, as well as for studying commonalities with heavy-ion systems, in particular in high-multiplicity events. In this communication, an overview of the most recent ALICE measurements of hidden and open HF hadrons in small and large collision systems, along with the comparison to the corresponding available theoretical calculations, will be discussed.

▲ **Measurements of (anti)(hyper)nuclei with ALICE.**
Barioglio L.
INFN, Sezione di Torino, Italia
The production mechanism of light (anti)(hyper)nuclei in hadronic collisions is a debated topic. Two classes of models are used to describe (hyper)nuclear production: the statistical hadronisation model (SHM) and the coalescence model. ALICE has measured the production of light (anti)(hyper)nuclei in different collision systems and energies. Small collision systems, such as pp and p-Pb collisions, are very important because the system size is comparable with, or lower than, the (hyper)nuclear size. In particular, hypertriton production in small systems is an ideal probe to discriminate different production models due to its large size relative to that of the particle-emitting source. In this communication, the most recent ALICE results about (hyper)nuclear production will be shown and compared with the predictions of SHM and coalescence models. Finally, the measurement of hypertriton lifetime and Λ separation energy will be shown.

▲ **Probing vorticity and strong force fields in relativistic heavy-ion collisions.**
Oliva L.
Dipartimento di Fisica e Astronomia, Università di Catania e INFN, Sezione di Catania
Relativistic heavy-ion collisions are characterized by the generation of a strong vorticity as well as intense electromagnetic fields, reaching the highest values ever observed in Nature.

Their impact on heavy-flavor particles, and in particular on the directed flow of D mesons, has been studied at RHIC and LHC energies by means of a relativistic Boltzmann transport approach, clarifying the powerful role of this observable in shedding light on the transport properties of the hot QCD matter formed in relativistic nuclear collisions. Vorticity and electromagnetic fields are also the main conventional mechanisms for particle spin polarization. However, they cannot explain the recent experimental data on spin alignment of vector mesons in heavy-ion collisions, while new insights come from a model that includes strong force fields and their local fluctuations, pointing to a hitherto unknown influence of the nuclear strong force.

Comunicazioni

Femtoscopic analysis of identical charged kaons in Pb-Pb collisions at 5.02 TeV.

Romanenko G. per la ALICE Collaboration
INFN and University of Bologna

Heavy-ion collisions at the LHC are believed to produce quark-gluon plasma (QGP), which is a state of matter with unbound partons. It behaves similarly to a (nearly) perfect fluid which is revealed by the presence of, for example, collective effects. The space-time properties of a QGP fireball can be studied using femtoscopic correlations, which allow to determine the spatial size of a particle-emitting source, to study its evolution dynamics and collective flow effects, etc. In this communication, we report results of one- and three-dimensional femtoscopic analyses of identical charged-kaon correlations in Pb-Pb collisions at 5.02 TeV measured by the ALICE experiment. The importance of kaon femtoscopy is to check if different model scenarios work equally well as for pions. The results show the presence of radial expansion of an emission source (*i.e.*, radial flow). The extracted one-dimensional radii presented as a function of collision multiplicity are compared with kaon source sizes obtained for different energy, Pb-Pb at 2.76 TeV, and collision systems: p-Pb at 5.02 TeV, and pp at 7 TeV. A comparison with calculations from the integrated hydrokinetic model (iHKM) is also performed.

A novel SiPM-based aerogel RICH detector for the future ALICE 3 apparatus at LHC.

Nicassio N. per la ALICE Collaboration
Università degli Studi di Bari, Italia e INFN, Sezione di Bari, Italia

The ALICE Collaboration is proposing a new apparatus, ALICE 3, to investigate the Quark Gluon Plasma properties for the LHC Runs 5 and 6. The measurements planned to address ALICE 3 physics goals require to identify charged particles over eight units of pseudorapidity ($|\eta| < 4$) and to achieve a better than 3σ e/π, π/K and K/p separation up to above 2 GeV/c, 10 GeV/c and 16 GeV/c, respectively. In this context, conceptual studies for the design of complementary Ring-Imaging Cherenkov (RICH) and Time-Of-Flight (TOF) detectors are ongoing. The state-of-the-art detector concept for the ALICE 3 barrel RICH consists in a proximity-focusing layout, using aerogel ($n = 1.03$ at $\lambda = 400$ nm) as Cherenkov radiator and a layer of Silicon Photomultipliers (SiPMs) for the photon detection. With the SiPM layer achieving a charged track time resolution of 20 ps, one could envisage merging ALICE 3 outer TOF and barrel RICH layers into a single one, thus considerably diminishing the overall costs. The latest barrel RICH specifications and performance simulations will be presented. The R&D challenges related to the proposed design will be also discussed.

Timing performance of monolithic sensors with additional gain.
Gioachin G. per la ALICE Collaboration
INFN e Politecnico di Torino
In preparation for the LHC Run 5 (2035) and 6, the ALICE Collaboration has submitted a proposal for a next-generation heavy-ion experiment, named ALICE 3, to be installed during the LHC Long Shutdown 4. The key features of this new experimental apparatus will be an exceptional pointing resolution and an excellent Particle IDentification (PID). To this end, a Time-Of-Flight system, made of silicon sensors, with an outstanding time resolution of 20 ps will play a crucial role. Several silicon technologies are under investigation to achieve this goal, and, among them, fully depleted CMOS sensors with an additional gain. A vigorous R&D is needed as the time resolution of CMOS sensors needs to be pushed significantly beyond the present state of the art to meet the demanding requirements of future-generation experiments. In particular, the results of the simulations performed to design the CMOS sensors with an additional gain will be presented. Moreover, the experimental results obtained in the tests of the first prototypes produced with a 110 nm technology will be also shown. The studies will be followed by an overview of the next steps.

Performance study of SiPM sensors for the dRICH detector at the ePIC experiment.
Occhiuto L., Fazio S.
Univesità della Calabria e INFN, Sezione di Cosenza
We report on the characterization of different types of Silicon Photomultipliers (SiPMs). SiPMs can detect and resolve single photons. They are considered as the baseline technology of choice to equipe the dual RICH (dRICH) detector at the ePIC experiment at the future Electron-Ion Collider. One of the downsides of SiPMs is the presence of a Dark Count Rate (DCR) caused by thermal electrons which also depends on the bias voltage applied to the sensor. Such an effect can be minimized by lowering temperature of the sensors. We will show several measurements of DCR at different temperatures (-20 °C, -25 °C, -30 °C). Furthermore, to estimate radiation damage to the sensors, we have exposed them to different doses of absorbed protons and neutrons at the Center for Proton Therapy at Trento and Legnaro National laboratory. The impact of these measurements for the user-case of the dRICH detector at ePIC will be discussed. These are critical to understanding how best to "control" the DCR, maintaining optimal dRICH detector performance over a long period of time and, in fact, making sure that the SiPMs are the best sensors to use.

The ALPHA experiment at CERN.
Urioni M. per la ALPHA Collaboration
Università di Brescia, Brescia, Italia
ALPHA (Antihydrogen Laser PHysics Apparatus) is an experiment of the Antiproton Decelerator (AD) at CERN in Geneva whose main objective is to study the properties of antihydrogen. Antihydrogen atoms are created in the experiment by combining antiprotons, which are produced by the AD, with positrons. The antihydrogen atoms are then trapped and studied using magnetic and electric fields. The experimental apparatus is divided in two sections, namely ALPHA-II and ALPHA-g. In the first one, through laser spectroscopy, the atomic orbital energy levels are studied and compared with those of hydrogen to test the CPT theorem. In ALPHA-g, the gravitational interaction between antihydrogen atoms and the Earth is investigated. The apparatus has been upgraded during LHC Long Shutdown 2 and commissioned during 2021. During the 2022 data taking, the experiment focused on the operation of the vertical trap of ALPHA-g and on the measurement of the gravitational interaction of antihydrogen. Few weeks were also devoted to spectroscopy in the ALPHA-II

apparatus. Details about the experimental apparatus, the measurement procedures and the physics results of the 2022 data taking will be presented.

Studio di processi di decadimento 2β del ^{150}Nd.

Leoncini A. ([1])([2]), Barabash A.S. ([3]), Belli P. ([1])([2]), Bernabei R. ([1])([2]), Boiko R.S. ([4])([5]), Cappella F. ([6])([7]), Caracciolo V. ([1])([2]), Cerulli R. ([1])([2]), Danevich F. ([2])([4]), Fang D.L. ([8]), Ferella F. ([9]), Incicchitti A. ([6])([7]), Kasperovych D.V. ([4]), Kobychev V.V. ([4]), Konovalov S.I. ([3]), Merlo V. ([1])([2]), Nisi S. ([9]), Poda D. ([10]), Polischuk O.G. ([4])([6]), Shcherbakov I.B.K. ([11]), Šimkovic F. ([12]), Tretyak V.I. ([4])([9]), Umatov V.I. ([3])

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([12]) *Comenius University, Bratislavia, Slovakia*

Il decadimento 2β del ^{150}Nd al primo livello eccitato 0_1^+ del ^{150}Sm ($E_{exc} = 740.5$ keV) è stato studiato tramite il setup sperimentale a basso fondo composto da quattro rivelatori HPGe (volume $\simeq 225$ cm^3 ciascuno) presso i Laboratori Nazionali del Gran Sasso dell'INFN. Un campione altamente puro di 2.38 kg di Nd_2O_3 è stato utilizzato come fonte dei raggi γ previsti dai decadimenti. Raggi γ di energie 334 keV e 406.5 keV emessi dopo la diseccitazione del livello 0_1^+ 740.5 keV del ^{150}Sm sono stati osservati negli spettri sia unidimensionali sia in coincidenza accumulati in 51237 h. Preliminarmente, l'emivita del ^{150}Nd relativa al decadimento $2\nu2\beta$ allo stato eccitato 0_1^+ del ^{150}Sm è stata determinata come $1.1^{+0.5}_{-0.3}(\text{stat})^{+0.2}_{-0.2}(\text{syst}) \times 10^{20}$ anni in buon accordo con i risultati degli esperimenti precedenti.

Aula P2 **ore 16:15 – 19:30**

Sezione I
Fisica nucleare e subnucleare
Presiede: Battaglieri M. (INFN, Sezione di Genova)

Relazioni su invito

▲ **The EIC physics case.**
Radici M.
INFN, Sezione di Pavia
The Electron-Ion Collider (EIC) is a new accelerator being built at the U.S. Brookhaven National Laboratory (BNL). The EIC will host collisions at high luminosity between electrons and ions ranging from proton to Uranium, with 70% polarized beams for electrons and light ions (proton, deuterium, helium, tritium) at variable center-of-mass energy between 20 and 140 GeV. The EIC physics case focusses on important open questions about the structure of hadrons: 1) How do properties of nucleon (mass, spin, ...) emerge from quark-gluon interactions inside it? 2) How do nuclear forces and binding emerge from the QCD dynamics of colored objects? 3) Does gluon density saturate at high energy, giving rise to a universal gluonic matter? I will briefly overview this physics case, highlighting some examples of the expected EIC impact on our current understanding of this field.

▲ **Nuove sfide di fisica adronica a JLab ed EIC.**
Contalbrigo M.
INFN, Sezione di Ferrara
Due grandi progetti negli Stati Uniti promettono misure senza precedenti basate su fasci di elettroni e bersagli nucleari polarizzati. Al Jefferson Lab, Newport News, VA, il nuovo fascio di alta intensità su bersagli fissi permette studi di precisione della dinamica dello stato confinato, e sensibilità a fenomeni rari con carattere interdisciplinare. Il nuovo collisore elettrone-ione EIC al Brookhaven National Lab, Upton, NY, è disegnato per esplorare i segreti dell'interazione forte fino alle condizioni estreme della saturazione gluonica. La relazione evidenzia il coinvolgimento dei ricercatori italiani, presenti fin dall'inizio con ruoli e contributi di primo piano.

Comunicazioni

● **Status dell'esperimento MEGII: Alla ricerca di cLFV.**
Venturini A. per la MEG II Collaboration
Istituto Nazionale di Fisica Nucleare, Sezione di Pisa, Italia e Dipartimento di Fisica, Università di Pisa, Italia
L'esperimento MEG II @ PSI cerca un segnale dal decadimento $\mu^+ \to e^+\gamma$ con una sensibilità sul singolo evento prevista di 6×10^{-14} (l'attuale limite superiore è $\mathrm{BR}(\mu^+ \to e^+\gamma) \leq 4.2 \times 10^{-13}$ posto dall'esperimento MEG). La scoperta dell'esistenza di un simile processo che viola la conservazione del sapore leptonico sarebbe l'evidenza di Nuova Fisica, oltre il Modello Standard. Per raggiungere il suo obiettivo, l'esperimento impiega il fascio continuo di muoni più intenso al mondo (fino a 10^8 μ^+/s) ed ha innovato il suo sistema di rivelatori per migliorare la risoluzione sulla misura delle variabili cinematiche delle

particelle di decadimento e ridurre il fondo sperimentale. Questo è un momento entusiasmante per la Collaborazione MEG II: il secondo anno di acquisizione dei dati di fisica si è appena concluso (dicembre 2022) e la pubblicazione dei risultati dell'analisi sulla prima serie di dati è prevista per quest'anno. In questa comunicazione esamineremo lo stato corrente e le prospettive future dell'esperimento alla luce di questi primi risultati, dopo due anni di presa dati.

Semi-Inclusive DIS with kaons using the CLAS12 experiment.

Vallarino S.
INFN, Sezione di Ferrara e Università degli Studi di Ferrara

In the CLAS12 experiment at Jefferson Lab, 12 GeV polarized electrons are scattered off (polarized) nucleons and the final-state particles are efficiently detected over a large solid angle. Precise Semi-Inclusive Deep Inelastic Scattering (SIDIS) studies, characterized by the measurement of at least one generated hadron together with the scattered electron, provide access to new types of Parton Distribution Functions (PDFs) and Fragmentation Functions (FFs) sensitive to specific aspects of the QCD dynamics. CLAS12 data on the single- and double-pion production channel have reached unprecedented statistical precision in the valence region. A Ring Imaging Cherenkov (RICH) detector has been realized to extend the SIDIS studies on the final states with kaons. This work describes the analysis of the Beam Spin Asymmetry in kaon electro-production, *i.e.*, the difference between the number of events measured in opposite states of beam helicity. The study will provide complementary data to the pion case and other experiments and access to the so-called transverse-momentum–dependent PDFs and FFs. The key role of the PID improvement provided by the RICH detector will be also detailed.

Charmed baryon-to-meson ratio *vs.* the event charged-particle multiplicity.

Dello Stritto L.
Università di Salerno

Recent measurements of charm-baryon production at midrapidity in proton-proton and proton-nucleus collisions show a significantly higher baryon-over-meson production yield ratios than in e^+e^- collisions, suggesting that the charm fragmentation is not universal across different collision systems. Thus, measurements of charm-baryon production are crucial to study the charm-quark hadronisation in proton-proton collisions and its difference with respect to in-vacuum fragmentation. Moreover, differential studies of heavy-flavour production as a function of the event charged-particle multiplicity provide insights into the role of multi-parton interactions in heavy-quark production. They can also address the relevance of colour-reconnection mechanisms in heavy-quark hadronization in pp, p-Pb, and Pb-Pb. The ALICE detector is well suited to detect charm baryons down to low p_T thanks to its excellent tracking, vertexing and particle identification capabilities. In this communication, the new results on Λ_c^+ baryon production and charmed baryon-to-meson ratios *vs.* the event charged-particle multiplicity measured by the ALICE Collaboration in pp, p-Pb, and Pb-Pb collisions will be presented.

Studying the proton structure: The FAMU experiment.

Vacchi A. per la FAMU Collaboration
INFN, Sezione di Trieste, Trieste, Italy

Significant progress has been made in the study of atomic and nuclear physics, the testing of QED, and the Standard Model (SM) thanks to experiments on muonic atoms. High-precision muonic atom experiments push the boundaries of precision in particle physics complementing that from high-energy colliders. Muonic hydrogen serve as the ideal testing

ground to examine the theoretical foundations through experimental results. Using laser spectroscopy, the FAMU Collaboration will measure the hyperfine splitting (hfs) in the ground state of muonic hydrogen. The hyperfine splitting in muonic hydrogen represents a case where the accuracy of QED calculations exceeds the accuracy of the known values of fundamental physical parameters. The Zemach radius is the physical quantity related to the electromagnetic properties of the proton that can be extracted. This provides a unique possibility for the measurement of low-energy proton magnetic structure with higher accuracy than that achievable in nuclear or particle physics experiments. We will discuss the current state and future prospects of this experiment, which makes use of the RIKEN-RAL muon facility's pulsed muon beam.

Misura dell'efficienza e della soglia di trigger del barrel di KLOE per lo studio del $\pi^0 \to \gamma\gamma$ con l'esperimento KLOE-2 a DAFNE.

Longo L. ([1])([2]), Curciarello F. ([3])
([1]) *Dipartimento di Fisica, Università della Calabria, Italia*
([2]) *INFN, Gruppo Collegato di Cosenza, Italia*
([3]) *INFN, Laboratori Nazionali di Frascati, Italia*

Il decadimento del pione neutro in due fotoni è un processo storicamente interessante, il cui calcolo teorico dell'ampiezza ha fornito non solo evidenze sull'esistenza di anomalie quantistiche (anomalia chirale), ma è considerato anche un test di cromodinamica quantistica (QCD), in particolare sul numero di gradi di libertà di colore. Sperimentalmente, esistono varie tecniche per il calcolo dell'ampiezza di decadimento: metodo diretto, metodo Primakoff e metodo collider. Utilizzando il metodo collider è possibile studiare l'ampiezza di decadimento $\Gamma(\pi^0 \to \gamma\gamma)$ attraverso il calcolo della sezione d'urto $\sigma(e^+e^- \to e^+e^-\gamma^*\gamma^* \to e^+e^-\pi^0 \to e^+e^-\gamma\gamma)$. In questa comunicazione viene presentata la misura dell'efficienza e della soglia di trigger del barrel dell'esperimento KLOE all'acceleratore e^+e^- DAFNE dei LNF, necessarie per la simulazione del segnale di interesse.

High-precision kaonic atoms X-ray spectroscopy with the SIDDHARTA-2 experiment at the DAΦNE collider.

Sgaramella F.
INFN, Laboratori Nazionali di Frascati, Italia

Kaonic atoms represent a unique laboratory for the study of the antikaon-nucleus interaction at threshold and investigate the low-energy QCD in the strangeness sector. State-of-the-art X-ray detectors allow to perform high-precision X-ray kaonic atoms spectroscopy, leading to fundamental input for nuclear, particle, and astrophysics research. The SIDDHARTA-2 experiment is performing a data taking campaign to carry out high-precision X-ray spectroscopy of various kaonic atoms, with a particular focus on the first measurement ever of the kaonic deuterium fundamental level to determine the isospin-dependent antikaon-nucleon scattering length and contribute to our understanding of the strong interaction in the strangeness sector. I will present the SIDDHARTA-2 experiment, the recent results obtained during the first phase of the experiment, in particular the most precise measurement of kaonic helium X-ray $L\alpha$ transition in gas and the first measurement ever of the M-type transitions, as well as the first measurement of several high-n transitions in other kaonic atoms. Finally, I will outline the prospects for the ongoing kaonic deuterium measurement and our future plans.

Secondary beams at Jefferson Laboratory.

Fulci A.
Università di Messina

The Thomas Jefferson National Accelerator Facility (JLab) is a national lab in the United States. It houses the Continuous Electron Beam Accelerator Facility (CEBAF), a set of two linear accelerators and recirculating arcs that can reach energies up to 12 GeV and currents up to 100 μA. Hadron physics fixed target experiments run in four experimental halls (A to D). Beam electrons not interacting with the hadron target in Hall-A are absorbed into a beam-dump (BD), a cylinder made up of aluminum disks refrigerated by flowing water. The interaction between the BD and electrons produces intense secondary beams which can be used to extend the physics program scheduled with the primary electron beam. Secondary beams include neutrinos, muons and (if it exists) light dark matter. Monte Carlo simulations using FLUKA and GEANT4 showed that an intense muon and neutrino flux, respectively, in the forward and in the upward directions, can be produced. The extended physics case includes precise measurement of proton radius via muon elastic scattering and coherent elastic neutrino-nucleus scattering.

Aula F8 - Maria Marinaro **ore 16:15 – 19:30**

Sezione II
Fisica della materia
Presiede: Palma M. (Università di Palermo)

Relazioni su invito

▲ **Counteracting phase diffusion through a realistic optical parametric oscillator.**
Olivares S. (1)(2), Cialdi S. (1)(2), Genoni M.G. (1)(2), Notarnicola M.N. (1)(2), Paris M.G.A. (1)(2)
(1) *Dipartimento di Fisica "Aldo Pontremoli", Università degli Studi di Milano, Italia*
(2) *Istituto Nazionale di Fisica Nucleare, Sezione di Milano, Italia*
We address the use of an optical parametric oscillator (OPO) to counteract phase diffusion and to demonstrate phase-noise reduction for coherent signals traveling through a suitably tuned OPO. We theoretically and experimentally show that there is a threshold value on the phase noise, above which the OPO can be exploited to "squeeze" phase noise. The threshold depends on the energy of the input coherent state, and on the relevant parameters of the OPO (gain and input-output and crystal loss rates). Applications to phase estimation assisted by a realistic OPO and in the presence of phase diffusion are also discussed. Here two scenarios are considered: the first one is the measurement of the phase of a noisy optical field, while the second involves a quantum estimation scheme of a phase shift imposed on a noisy probe. In both cases, we prove that an OPO may lead to a partial or full compensation of the noise.

▲ **A plug-n-play approach to quantum photonics.**
D'Auria V.
Université Côte d'Azur, Institut de Physique de Nice, INPHYNI
Quantum technologies exploiting guided optics and integrated photonics represent a field in fully expansion due to the possibility of covering a wide panel of quantum light-based applications. In this talk, I will present our results on the development of telecom-compatible solutions for quantum optics experiments in the continuous variable regime of quantum information encoding. A first part of the talk will focus on the manipulation of quantum states of light, proving the possibility of implementing scalable and reconfigurable setups following a plug-n-play approach. In what follows, a proposal will be presented and discussed on the possibility of generating and manipulating complex quantum states, carrying non-Gaussian features, by exploiting a multimode approach as a key strategy.

▲ **Two-qubit entanglement distillation via controlled indistinguishability effects.**
Lo Franco R.
Dipartimento di Ingegneria, Università di Palermo
Entanglement is an essential resource at the heart of quantum-enhanced technologies. Nonetheless, noise and environmental interactions are inevitable, leading to decoherence and entanglement degradation. Hence, quantum information and computation science has to face the challenge of preserving quantum resources, such as entanglement, under given noisy situations. In this talk, we introduce an entanglement distillation method that operates within the framework of spatially localized operations and classical communication (sLOCC) and

makes use of spatial overlap between identical qubits and particle statistics imprint. We discuss the required conditions for the maximum entanglement distillation out of mixed states. As an application, we finally give a description of the success probability for distilling entanglement from thermal Gibbs states and Werner-like input states. Such a method may pave the way towards quantum repeaters in quantum networks composed of controllable identical particles.

Comunicazioni

Riduzione della $g^2(0)$ di sorgenti di singolo fotone tramite rivelatori photon number resolving.

Bruscino C. ([1]), Ercolano P. ([1]), Ejrnaes M. ([2]), Salvoni D. ([3]), Zhang C. ([3]), Li H. ([4]), You L. ([4]), Parlato L. ([1])([2]), pepe G.P. ([1])([2])

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Una delle richieste fondamentali dei protocolli di Quantum Key Distribution (QKD) è l'uso di sorgenti di singolo fotone per l'invio di informazioni codificate. Il caso ideale di sorgenti che emettono un singolo fotone per impulso con alta efficienza, però, è ancora solo un modello teorico. Ciò porta all'uso di sorgenti non ideali che emettono impulsi con componenti a più fotoni con una probabilità non nulla, come nel caso di sorgenti Spontaneous Parametric Down Conversion (SPDC). Una strategia per migliorare la sicurezza dello scambio di chiavi è la caratterizzazione, in tempo reale, delle componenti a più fotoni della sorgente mediante l'uso di rivelatori Photon Number Resolving (PNR), i quali sono in grado di risolvere fino ad un certo numero di fotoni per impulso. In questo lavoro, è stata studiata la riduzione delle componenti a più fotoni di una sorgente SPDC tramite la stima della funzione di correlazione del secondo ordine, $g^2(0)$, usando diversi modelli teorici di rivelatori PNR.

Raman study of charge-density-wave phase transitions in $1T$-$TaSe_2$.

Ruggeri M. ([1]), Sayers C. ([2]), Romano V. ([2]), D'Angelo G. ([1])

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([2]) *Dipartimento di Fisica, Politecnico di Milano, Italy*

Charge density wave (CDW) refers to the periodic modulation of electronic distributions accompanied by the lattice distortion. The capacity to control collective electron states is a main issue of materials research since may allow for the development of novel devices. Transition-metal dichalcogenides (TMDs) $MX2$ (M = Ti, Nb, Ta; X = S, Se, Te) exhibit a rich collection of charge density wave phases which coexist or compete with superconductivity. Though intensively studied, the mechanisms of CDWs and superconductivity in TMDs are still under debate. Here we have performed systematic *in situ* low-temperature Raman measurements and angle-resolved Raman scattering study on tantalum diselenide ($1T$-$TaSe_2$) to identify the phonons involved in the CDWs phase. The lattice distortion associated to the CDW phase coincides with new Raman peaks resulting from zone-folding of phonon modes from middle regions of the original Brillouin zone back to Γ. Furthermore, combining the obtained polarization data with DFT calculations, we were able to assign the vibrational symmetry of the Raman-active modes to each observed phonon mode.

Emettitori di singolo fotone da bolle di TMD ripiene di idrogeno.

Cianci S. ([1]), Blundo E. ([1]), Tuzi F. ([1]), Pettinari G. ([2]), Olkowska-Pucko K. ([3]), Parmenopoulou E. ([1]), Peeters D.B.L. ([4]), Miriametro A. ([1]), Taniguchi T. ([5]), Watanabe K. ([6]), Babinski A. ([3]), Molas M.R. ([3]), Felici M. ([1]), Polimeni A. ([1])

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I materiali bidimensionali semiconduttori, in virtù del loro spessore atomico e del loro vantaggioso rapporto superficie/volume, hanno dimostrato il loro potenziale nel campo dell'optoelettronica. La loro straordinaria resistenza a deformazioni meccaniche (strain) pare, inoltre, essere alla base della generazione di emettitori di singolo fotone, fondamentali per la computazione quantistica. I due elementi necessari per l'emissione di luce quantistica, *i.e.*, basse temperature e strain, sono qui ottenuti tramite un'innovativa procedura in cui fasci di protoni formano bolle sulla superficie dei cristalli semiconduttori. Tali bolle, spesse un singolo strato, sono deformate dalla pressione del gas di idrogeno sottostante. Per prevenirne lo sgonfiamento a basse temperature, a seguito della condensazione dell'idrogeno, queste sono coperte con sottili strati di nitruro di boro esagonale, il quale le mantiene in forma fino alle temperature necessarie per la comparsa degli emettitori. Grazie all'utilizzo di maschere definite litograficamente si ottengono, pertanto, array ordinati di emettitori in posizioni predefinite, potenzialmente integrabili con cavità e circuiti fotonici.

Optical properties of Xene heterostructures.

Bonaventura E. ([1])([2]), Dhungana D.S. ([2]), Martella C. ([2]), Grazianetti C. ([2]), Macis S. ([3]), Lupi S. ([3]), Bonera E. ([1]), Molle A. ([2])

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The dimensional reduction brought about by the advent of 2D materials has opened new routes for nanoelectronic and photonic applications. In this context, the Xenes (artificial graphene-like monoelemental lattices) represented a new forefront due to their peculiarities. Unfortunately, the high chemical reactivity and the strong hybridization effects with native substrates have limited their use to date: silicene on Ag and tin on Al_2O_3 are two of the most striking examples. The effect of the substrates on the properties of Xenes provides an interesting framework within which their epitaxial growth can be engineered. Vertical stacks of different layers of atomically thin films make it possible to create novel structures and control their electronic response. Such stacks could offer an unprecedented degree of freedom in the discovery of new functionalities. Here, we report on the optical properties of silicene-stanene on Ag and stanene-graphene on Al_2O_3 heterostructures, made accessible by spectroscopic measurements in the MIR-UV spectral range and by Raman spectroscopy. Our results highlight the role of the interlayer in decoupling the overlying Xene from the native substrate.

The role of water at the interface with TiO_2 for H_2 photoproduction.

Verduci R. [1], D'Angelo G. [2], Perathoner S. [1], Centi G. [1]

[1] *Dipartimento di scienze chimiche, biologiche, farmaceutiche ad ambientali, Università degli studi di Messina, Italia*

[2] *Dipartimento di scienze matematiche e informatiche, scienze fisiche e scienze della terra, Università degli studi Messina, Italia*

The interfacial water structure on solid surfaces plays an important role in a broad range of fundamental and applied research fields including photocatalysis for water splitting. Due to the complexity of these systems, a deep knowledge of the water/solid interface is lacking and several questions, regarding i) the probability of molecular or dissociative water adsorption, ii) the strong influence that a particular surface (geometry, morphology and chemical composition) has on the water organization and iii) how these aspects are related to catalytic reactions, are still unanswered. Motivated by these reasons, in this work, by performing a Fourier transform infrared study on two TiO_2 anatase semiconductors (undoped and B-doped), we provide new insight into the molecular level understanding of the hydrogen bond network. As main result, since the physicochemical and morphological characteristics of the investigated samples are similar, we explain the enhancement in the H_2 production of about 4.5 times in the B-doped TiO_2 with respect to the pure TiO_2, as due to the different arrangement of water molecules on the TiO_2 surfaces.

Multispectral plasmonic metasurface to monitor protein denaturation via surface-enhanced infrared spectroscopy.

Esposito E. [1], Di Meo V. [1], Moccia M. [2], Sanità G. [1], Crescitelli A. [1], Lamberti A. [3], Galdi V. [2], Rendina I. [1]

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Surface-Enhanced InfraRed Absorption (SEIRA) spectroscopy is a powerful tool to overcome the limitation offered by the standard IR spectroscopy in the case of very small amount of analyte to be detected. We apply SEIRA spectroscopy to monitor the denaturation process of a surface-bound protein A monolayer. Our platform relies on plasmonic metasurface comprising different spatial subregions ("pixels") that are engineered to exhibit different resonances covering the infrared region of the electromagnetic spectrum that is matched to the vibrational modes of the Amide groups. We are able to determine changes in the Amide I and Amide II vibration coupled modes, by comparing the SEIRA spectra pertaining to the native and a denatured state induced by a *p*H variation. In particular, we observe evident red-shifts in the principal Amide I and Amide II vibration coupled modes (attributable to the breaking of hydrogen bonds), which result in insurmountable barriers for refolding. Thanks to the strong field localization, and consequent enhancement of the light-matter interactions, our sensing platform can operate with an estimated detection limit of about 3 fmol of molecules.

Comb-assisted Lamb-dip spectroscopy of the mercury intercombination line at 253.7 nm for metrological applications.

Gravina S., Chishti N.A., Di Bernardo S., Gianfrani L.

Dipartimento di Matematica e Fisica, Università degli Studi della Campania "Luigi Vanvitelli", Italia

The saturated absorption spectrum of mercury vapors is measured in coincidence with the $6s^2\ {}^1S_0 \rightarrow 6s6p\ {}^3P_1$ intercombination transition at 253.7 nm. Coherent radiation in the

deep-UV region is produced by means of a double stage of second harmonic generation of a 1014.8 nm external cavity diode laser (ECDL) in a pair of nonlinear crystals. The ECDL frequency is tightly locked to the nearest tooth of a self-referenced optical frequency comb synthesizer, traceable to a GPS-disciplined time base signal provided by a Rb-clock. Absolute measurements of the sub-Doppler line-center frequency with an overall relative accuracy of a few parts over 10^{11} have been obtained by means of a first-derivative detection method, using a modulation transfer technique. Moreover, we present the first high-precision determination of the pressure-broadening coefficient due to Hg-Hg collisions by analyzing the Lamb-dip profile at different vapor pressures. The results of the present study are important for the ongoing experiment of temperature metrology based upon Doppler-broadening Hg spectrometry and aimed to implement the unit kelvin.

Aula F4 - Henrietta Leavitt **ore 16:15 – 19:30**

Sezione III
Astrofisica
Presiede: Capaccioli M. (Università di Napoli Federico II e INAF)

Relazioni su invito

▲ **Una armada (da Terra e dallo spazio) alla conquista dei pianeti extrasolari.**
Ragazzoni R.
Dipartimento di Fisica e Astronomia, Università degli Studi di Padova e INAF - Astronomical Observatory of Padova
Durante il perielio della cometa di Halley del 1986, ben cinque sonde intercettarono l'astro periodico nel suo ultimo passaggio nei paraggi del Sole. Di queste, che furono subito soprannominate Halley armada, i risultati più eclatanti furono raggiunti dalla sonda europea. A distanza di circa mezzo secolo, almeno sei sonde, di cui tre europee, una francese e due statunitensi, in questa analogia sintattica che spero il lettore mi perdonerà, hanno preso o stanno per prendere il volo alla conquista di nuovi mondi che albergano intorno a stelle differenti dal nostro Sole. COROT, KEPLER, TESS, CHEOPS, PLATO e ARIEL sfruttano le condizioni di osservabilità ininterrotta e priva di alterazioni dovute alla scintillazione atmosferica per indivduare nuovi pianeti, tracciare una prima statistica (da cui emergono numerose inattese evidenze), misurare con precisione diametro e periodi orbitali, individuare terre gemelle alla nostra per dimensioni e tipologia di stella madre, e finanche misurarne l'atmosfera, utilizzando il metodo dei transiti. Complementari ed essenziali, osservazioni spettroscopiche da Terra completano questa nuova armada pronta a svelare mondi alieni mai immaginati.

Comunicazioni

● **Global architecture of planetary systems (GAPS): searching for and characterizing exoplanets with TNG.**
Claudi R. on behalf of the GAPS Collaboration
INAF-Astronomical Observatory of Padova, Padova e Dipartimento di Matematica e Fisica, Università Roma Tre, Roma, Italy
GAPS project is an Italian collaboration started in 2012 and aimed to exploit the high resolution spectrographs (HARPS-N in the visible and GIANO-B in the NIR) at the Telescopio Nazionale Galileo (TNG) to search for and characterize extrasolar planets. In its first phase (ended in 2017) the project aimed to search new planets in known planetary systems and around other peculiar stars (low metallic and M stars) by means of high precision radial velocity time series. In 2017 the second phase of GAPS started, triggered by the implementation of the new TNG observing mode GIARPS that allows the simultaneous use of HARPS-N and GIANO-B. In this second phase, GAPS is devoted to the studies of young planets and planetary atmospheres and is still ongoing. In its 12 years long history, the project produced more than 50 refereed papers and discovered about 30 new planets, revised and refined several planetary masses, and characterized a bunch of transiting system analyzing their Rossiter McLaughlin effects. Furthermore, in the last 5 years GAPS identified CH_4, NH_3, CO, C_2H_2, H_2O, HCN, CO_2 molecules in the atmospheres of different transiting planets.

Atmospheric characterization of ultra-hot Jupiters with CHEOPS.
Singh V., Scandariato G., Pagano I.
INAF, Osservatorio Astrofisico di Catania, Catania, Italy
CHEOPS (CHaracterising ExOPlanets Satellite) is a European space telescope that aims to provide ultra-high precision photometry of stars hosting transiting exoplanets. After more than three years in orbit, the mission has just been extended. *CHEOPS* has successfully determined fundamental properties of selected exoplanets such as their size and atmospheric characteristics. Additionally, in some cases, it also led to the host star and system characterization. In this regard, we present key results from our *CHEOPS* observations of three ultra-hot Jupiters, namely WASP-43 b, WASP-178 b, and KELT-20 b. We studied the atmospheric properties of these exoplanets by observing the host star during several occultations of its planetary companion. We precisely measured the decrease in the star's luminosity, known as the occultation depth, which measures the planet's brightness and is related to its temperature and reflectivity. Furthermore, we provide constraints on the planet's atmospheric characteristics like its composition, temperature-pressure profile, geometric albedo, weather conditions and energy budget.

Fotometria di pianeti extrasolari e stelle giovani presso l'Osservatorio Polifunzionale del Chianti.
Betti L. ([1])([2]), Pace E. ([1])([2]), Stanga R. ([1])([2]), Claudi R. ([3]), Ciantini R. ([1])([2]), Michelagnoli M. ([1])([2]), Naponiello L. ([1])([2]), Biagini A. ([1])([4])
([1]) *Osservatorio Polifunzionale del Chianti, Università di Firenze, Italia*
([2]) *Dipartimento di Fisica ed Astronomia, Università di Firenze,Italia*
([3]) *INAF - Osservatorio Astronomico di Padova, Padova, Italia*
([4]) *INAF - Osservatorio Astronomico di Palermo, Palermo, Italia*
L'Osservatorio Polifunzionale del Chianti (OPC) - Università degli Studi di Firenze si occupa dello studio di curve di luce di pianeti extrasolari, di Young Stellar Object (YSO) e stelle variabili. Nell'ambito della ricerca degli esopianeti l'OPC collabora con: NASA - TESS, ESA - Ariel Exoclock, INAF - GAPS, svolgendo campagne osservative con lo scopo di determinare la presenza di falsi positivi in sistemi ancora non confermati, aggiornare i cataloghi contenenti le effemeridi di esopianeti in vista di future missioni spaziali e anche per la ricerca di TTVs. Relativamente a YSO e stelle variabili all'OPC sono state osservate regioni di formazione stellare IC 1396A, IC 1396N e V1298Tau per studiare l'attività di stelle giovani collaborando con INAF OAA, INAF OAPa e INAF-OAPd. Seguendo la vocazione dell'OPC alla formazione, il gruppo di ricerca all'OPC è ben integrato da giovani assegnisti, dottorandi, neolaureati e laureandi dell'Università di Firenze, Roma Tor Vergata e Palermo, con i quali è stato possibile anche mettere a punto la strumentazione, rendendola disponibile alla comunità scientifica per un ampio campo di misure fotometriche.

Characterise exoplanetary atmospheres using Quantum Machine Learning.
Zingales T., Piotto G.
Dipartimento di Fisica e Astronomia "Galileo Galilei", Università degli Studi di Padova, Padova, Italy e INAF, Osservatorio Astronomico di Padova, Padova, Italy
Quantum Computing aims to revolutionize the way we study exoplanets. In particular atmospheric studies could be accelerated incorporating the latest advancements in quantum machine learning (QML). QML could accelerate the study of exoplanetary atmospheres by enabling us to more accurately model their complex chemistry and physics. QML could also be used to analyze large datasets of exoplanetary spectra more quickly and accurately than classical algorithms. Spectroscopic observations provide valuable information about the composition of exoplanetary atmospheres, but analyzing these data requires sophisticated

statistical techniques that can be computationally intensive. QML algorithms could be used to analyze these spectra more efficiently, allowing us to extract more information from each observation and to process larger datasets more quickly. The development of QML algorithms for studying exoplanetary atmospheres has the potential to significantly accelerate our progress in this field, enabling us to better understand the nature of exoplanets and to identify promising targets for future study.

● **Probing exoplanet atmospheres with the JWST.**
Mancini L.
Department of Physics, University of Rome "Tor Vergata"
The JWST Transiting Exoplanet Community Director's Discretionary Early Release Science (JTEC ERS) program has observed a single exoplanet's transmission spectrum with different instrument configurations to test their capabilities and provide lessons learned for the community. The target, WASP-39b, is a hot giant planet at 215 pc from Earth, with a mass similar to Saturn but a radius in excess of Jupiter, resulting in an extended atmosphere. The host is a G8V-type star with little stellar activity and elemental abundance patterns that are nearly solar. Its quiet host and extended atmosphere make WASP-39b an ideal exoplanet for transmission spectroscopy observations. Using three of its instruments, the JWST observed WASP-39 for more than 40 hours in July 2022 at IR wavelenghts that were hitherto inaccessible. As a member of the JTEC ERS program, I will report on these observations that lead to unprecedented discoveries, such as the first detection in the atmosphere of an exoplanet of carbon dioxide and sulfur dioxide, the latter produced by chemical reactions triggered by highly energetic radiation from the parent star of the planet.

● **A super-massive Neptune-sized planet in the hot-Neptune desert.**
Naponiello L.
Department of Physics, University of Rome "Tor Vergata", Rome, Italy, Department of Physics and Astronomy, University of Florence, Florence, Italy e INAF, Turin Astrophysical Observatory, Pino Torinese, Italy
The paucity of Neptune-type planets at short orbital periods was recognised in the statistical studies of exoplanet populations and is known as "hot-Neptune desert". As many Neptune planets have been discovered with longer orbital periods, this dearth is not caused by observational biases but primarily by atmospheric photo-evaporation effects. Since then, the desert has been increasingly populated with planets having a wide range of different and, in some cases, unusual characteristics. The study of exoplanets that have experienced unconventional evolutionary processes offers a novel opportunity to enhance our current understanding of planetary formation and composition theories. We report the discovery of a transiting Neptune-sized exoplanet orbiting a dwarf star every 1.24 days. This planet has almost twice the mass of any other Neptune-sized planet known, which implies that it is dominated by heavy elements, and is located in the middle of the Neptunian desert. The remarkable properties of this new planet could be the result of multiple proto-planets collisions or the final state of an initially high-eccentricity proto-planet which migrated closer to its parent star.

Relazioni su invito

▲ **Recenti sviluppi e prospettive nella ricerca sui sistemi esoplanetari.**
Pagano I.
INAF - Osservatorio Astrofisico di Catania
A quasi trent'anni dalla scoperta del primo pianeta in orbita attorno a una stella di tipo solare, sono stati catalogati circa 5500 pianeti in quasi 4000 sistemi planetari. Diversi sono i

metodi utilizzati per individuare nuovi pianeti, spesso tra loro complementari, e diverse le tecniche adottate per ricavare informazioni sempre più precise sugli stessi e sui sistemi planetari a cui appartengono. Lo scenario osservato mette in evidenza una ampia varietà di tipologia di pianeti e una grande diversità nelle architetture dei sistemi esoplanetari. Comprendere l'origine della varietà di pianeti e sistemi planetari richiede la classificazione accurata delle proprietà fisiche dei pianeti e delle loro orbite; lo studio delle atmosfere planetarie, la cui composizione spesso mantiene traccianti delle fasi iniziali di formazione; la conoscenza delle proprietà della stella che ospita il sistema planetario; lo studio dell'interazione stella-pianeta. Dopo una panoramica sui principali risultati e sulle domande ancora aperte, mi soffermerò ad illustrare gli sviluppi attesi con l'avvento di nuovi strumenti dedicati allo studio dei sistemi esoplanetari da terra e dallo spazio.

▲ **Microlensing exoplanets from ground and space based surveys: the Roman Space Telescope microlensing survey.**

Calchi Novati S.
IPAC, Caltech, Pasadena, USA

Microlensing, with about 200 planetary systems known to date, is a key technique for the search and the characterization of exoplanets. In particular, microlensing allows to access relevant parts of the physical parameter spaces which are currently difficult to probe by other methods. As a main point, microlensing is sensitive to planets in bound systems located far enough (of order of a few AU) from their host star, beyond the snow line (a key location in the framework of planet formation theories), and is sensitive to low mass planets, in principle down to below Earth mass analogs. Additionally, microlensing is sensitive to planets distant from the solar neighbourhood, all the way to the Galactic bulge and in principle also to extragalatic planets. Finally, microlensing is sensitive to unbound planetary systems ("free floating planets"). In this summary I will focus on current results from ground-based surveys, the space-based Spitzer microlensing programs, which lasted 6 years, and the forecoming exoplanet microlensing survey with the Nancy Grace Roman Space Telescope.

Comunicazioni

● **Microlensing in the Gaia era.**

Rota P., Bozza V.
Dipartimento di Fisica E. Caianiello, Università Degli Studi di Salerno

Microlensing is a method that has become fundamental not only for the discovery of exoplanets but also for finding binary or multiple systems in the disk and in the galactic bulge. For this purpose Gaia plays a crucial role with more than 350 microlensing events detected and over 1700 predicted using astrometric simulations. Its importance lies in the fact that most of the observed microlensing events occur in the galactic disk, where the duration of the event is usually such that parallax and orbital motion effects can be detected. Here we present some interesting results, focusing in particular on events such as Gaia16aye, a binary lens where the full orbital motion solution has been calculated, or Gaia21blx, where a new interesting method has been introduced in order to explain this peculiar case. The source is fainter than the lens and, with the assumption that the blend flux is generated by the lens, the Gaia parallax is the flux-weighted average of the parallaxes of lens and source. Using several constraints we are able to derive the physical parameters of the lens.

● **Identifying exoplanets by Deep Learning. A fast and effective Convolutional Neural Network for classification of TESS candidates.**

Fiscale S. ([1])([2]), Inno L. ([2])([3]), Rotundi A. ([1])([2]), Ciaramella A. ([2]), Ferone A. ([2]), Magliano C. ([3])([4]), Cacciapuoti L. ([5]), Covone G. ([3])([4])

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(2) *Science and Technology Department, University of Naples "Parthenope", CDN, IC4, Naples, Italy*
(3) *INAF - Osservatorio Astronomico di Capodimonte, Napoli, Italy*
(4) *Dipartimento di Fisica "Ettore Pancini", Università di Napoli Federico II, Napoli, Italy*
(5) *European Southern Observatory, Garching bei Munchen, Germany*

In the detection of new planets, NASA's Transiting Exoplanet Survey Satellite (TESS) is providing us with thousands of periodic transit signals, or events. Typically, the human inspection is the process determining if an event is due to a transiting planet. However, because this inspection is both a slow and not objective process, several Machine Learning (ML) techniques have been proposed to tackle these issues. Here, we will present a ML model we developed to identify planet candidates in TESS data. Specifically, our model consists of a Convolutional Neural Network (CNN) we properly trained to perform a fast and effective classification of unseen events. When applied on a set of unseen TESS events, our CNN achieves a precision of 86% and recall of 89%. The high reliability shown by our network suggests its potential use in identifying new Earth-like planets in a subset of TESS Input Catalog stars. Experimental results and network architecture will be discussed more in detail in the presentation.

A systematic validation of hot Neptunes in TESS data.

Magliano C. (1), Covone G. (1), Cacciapuoti L. (2), Inno L. (3), Oliva F. (4), Pagano I. (5), Rotundi A. (3), Fiscale S. (3)
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(2) *European Southern Observatory, Garching bei Munchen, Germany*
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(4) *Istituto di Astrofisica e Planetologia Spaziali, INAF, Rome, Italy*
(5) *INAF, Osservatorio Astrofisico di Catania, Catania, Italy*

Our galaxy is inhabited by a great variety of exoplanets, much different from those of our own Solar System. The vast majority of close-in planets are massive hot Jupiters capable of holding their atmosphere against the stellar photoevaporation or small rocky planets completely drained by the stellar radiation. However, we observe an unexpected lack of highly irradiated Neptune- and Saturn-like planets orbiting their host star in less than 4–10 days. This poorly populated region of the planetary period-radius space is known as the "Hot Neptune Desert" and represents an open question within the field of theoretical astrophysics. Different physical scenarios have been proposed to explain the boundaries that delimit the Desert region. Here, we will show our latest results uniformly vetting 250 hot Neptune TESS candidates with a two-step vetting technique along with follow-up observations. We found 9 high-priority TESS candidates within the Desert, two of which were statistically validated, *i.e.*, TOI-1288 b and TOI-277 b. Future atmospheric characterization of these objects could offer a unique opportunity to unveil the mistery behind their rarity.

TESS search for substellar companions through Pulsation Timing of dSct.

Vaulato V.
University of Geneva

The Pulsation Timing technique (PT) is a method to discover and characterise exoplanets orbiting early-type, main-sequence oscillating stars, such as Delta Scuti. Through the so-called Light-Travel-Time-Effect (LTTE), their pulsation period might be phase-shifted because a massive companion makes the star wobbling around the common barycentre of the system. PT is an alternative technique to the most exploited search methods: radial velocities and

transits. PT can be successfully applied when long, uninterrupted, high-precision photometric series are available, such as with Kepler and TESS. In this talk, I am presenting the pioneering and pilot analysis me and my co-authors carried out to understand the potential of PT as applied to TESS data, as well as the first results we obtained.

A code for the computation of microlensing of multiple systems

Saggese V. ([1])([2]), Bozza V. ([2])([3])
([1]) *Dipartimento di Fisica "Ettore Pancini", Università di Napoli Federico II, Napoli, Italy*
([2]) *Istituto Nazionale di Fisica Nucleare, Sezione di Napoli, Napoli, Italy*
([3]) *Dipartimento di Fisica "E.R. Caianiello", Università di Salerno, Fisciano, Italy*

Microlensing is a particular case of gravitational lensing in which both lens and source are stellar mass objects and where the image separation is too small to be resolved; we can detect an apparent amplification of the brightness of the source in a typical bell-shaped light curve. Microlensing enables us to study a variety of objects and it is the most promising technique for finding Earth-mass planets located beyond the snowline; planets in this region typically have orbital periods of many years and are mostly inaccessible to other planets detection methods. The computation of microlensing light-curve is extremely time-consuming, modelling of individual microlensing events is a process that can last several months. The release of VBBinaryLensing code (based on the contour integration method) represents a considerable advance in the field. Here we present an upgrade of this code that can also be applied to analyse systems with multiple lenses, *e.g.*, triple star systems, host star with two planets in the lensing zone or even planetary systems with exomoons. The possibility of modelling multiple systems is essential in view of new missions, in particular the Roman Space Telescope.

Ariel Space Telescope: innovazione per la realizzazione di nuove ottiche.

Guerriero E. per conto dell'Ariel Telescope Assembly Team
INAF Osservatorio Astronomico di Palermo

Ariel è una missione VIS/IR finanziata da ESA che sarà lanciata nel 2029 ed avrà come obiettivo l'osservazione di un target di circa 1000 esopianeti per studiarne le atmosfere sia in composizione chimica che in efemeridi. Ariel sarà la prima missione spaziale progettata appositamente per tale scopo. L'intervento vuole dare una panoramica del progetto spaziale, in particolare, verrà enfatizzato il contributo italiano alla realizzazione del telescopio. Il telescopio sarà un Cassegrain fuori asse con uno specchio primario parabolico a forma ellittica di dimensioni ragguardevoli (1.1×0.7 m di area ottica) totalmente realizzato in alluminio nudo. Ad oggi non è mai stato realizzato uno specchio di tali dimensioni in alluminio per osservazioni nell'Infrarosso e per questo il team italiano, supportato dall'industria, ha pianificato in fase B1 di progetto una campagna di sviluppo, qualifica e validazione di una serie di processi di lavorazione per tali ottiche. Saranno illustrati in particolare come sono stati affrontati i processi di Trattamento Termico, Diamond Turning, Lucidatura e Coating, per ottenere ottiche lucidate in alluminio di grandi dimensioni.

Aula F3 - Maria Telkes **ore 16:15 – 19:30**

Sezione IV
Geofisica e fisica dell'ambiente
Presiede: Pace G. (ENEA, Roma)

Relazioni su invito

▲ **ITINERIS – Italian Integrated Environmental Research Infrastructures System.**
Pappalardo G.
Consiglio Nazionale delle Ricerche
The ITINERIS project will build the Italian Hub of Research Infrastructures in the environmental scientific domain for the observation and study of environmental processes in the atmosphere, marine domain, terrestrial biosphere, and geosphere, providing access to data and services and supporting the Country to address current and expected environmental challenges. ITINERIS coordinates a network of national nodes from 22 RIs (18 from the environmental domain, 2 from agri-food with strong link with the environment and 2 from the PSE domain, supporting services for the marine domain). The main goal is to develop cross-disciplinary research in environmental sciences through the use and re-use of existing (or pre-operational) data and services and new observations, to address scientifically and societally relevant issues such as sustainable use of natural resources, implementation of Nature-Based Solutions, Green and Blue Economy, pollution reduction, critical zone and ecosystem management and restoration, carbon cycle, mitigation of the downstream effects of climate and environmental change.

▲ **Il supersito BAQUNIN (Boundary-layer Air Quality analysis Using Network of Instruments) per la ricerca atmosferica e la validazione dei dati satellitari nell'area di Roma.**
Di Bernardino A. ([1]), Iannarelli A.M. ([2]), Bucci S. ([2]), Casadio S. ([2])([3]), Bassani C. ([4]), Cadau E.G. ([2])([3]), Campanelli M. ([5]), Casasanta G. ([5]), Diamoz H. ([6]), Falasca S. ([1]), Ferrante N. ([2]), Marcozzi F. ([2]), Mevi G. ([2]), Siani A.M. ([1]), Cardaci M. ([2]), Dehn A. ([3]), Goryl P. ([3])
([1]) *Dipartimento di Fisica, Università Sapienza, Roma, Italia*
([2]) *SERCO Italia SpA, Frascati, Roma, Italia*
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([4]) *Istituto sull'Inquinamento Atmosferico, CNR-IIA, Monterotondo, Roma, Italia*
([5]) *Istituto di Scienze dell'Atmosfera e del Clima, CNR-ISAC, Roma, Italia*
([6]) *ARPA Valle d'Aosta, Saint-Christophe, Aosta, Italia*
BAQUNIN raccoglie misure superficiali e colonnari di variabili meteorologiche, proprietà ottiche di aerosol, nubi e gas in traccia, con il supporto di modellazione numerica, dal 2017. L'osservatorio è promosso da ESA ed EUMETSAT per creare un'infrastruttura di ricerca volta alla validazione di prodotti satellitari atmosferici presenti e futuri e allo studio dello strato limite planetario. La peculiarità dell'osservatorio è il coinvolgimento di strumenti di telerilevamento attivi e passivi installati in diversi punti di misura. Infatti, BAQUNIN è costituito da tre siti localizzati nel centro di Roma (Sapienza Università di Roma) e nelle limitrofe zone semi rurali (CNR-ISAC) e rurali (CNR-IIA). BAQUNIN è consorzialmente gestito da università (Sapienza), enti di ricerca (CNR-ISAC, CNR-IIA, ARPA Valle d'Aosta)

e società private (SERCO) che garantiscono il funzionamento della strumentazione e la produzione di dati di alta qualità. I dati sono liberamente distribuiti attraverso il sito web del progetto e i portali di network internazionali cui alcuni strumenti appartengono. Qui viene presentato l'osservatorio, fornendo informazioni sulle sue potenzialità scientifiche.

▲ **Analisi della variabilità di gas ad effetto serra presso il sito atmosferico di Monte Cimone (Italia, 2165 m asl).**

Cristofanelli P. (1), Calzolari F. (1), Trisolino P. (1), Putero D. (2), Fratticioli C. (1), Busetto M. (1), Bonasoni P. (1), Calidonna C.R. (3), Biron D. (4), Amendola S. (4), Maione M. (5), Arduini J. (5)
(1) *ISAC-CNR, Bologna*
(2) *ISAC-CNR, Torino*
(3) *ISAC-CNR, Lamezia Terme*
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Presso Monte Cimone (2165 m s.l.m.), la vetta più elevata degli Appennini settentrionali, si trova una stazione globale del programma Global Atmosphere Watch dell'Organizzazione Mondiale per la Meteorologia. Tale stazione è composta dall'Osservatorio Meteorologico dell'Aeronautica Militare (CAMM Monte Cimone) e dall'Osservatorio "O. Vittori" gestito dal Consiglio Nazionale delle Ricerche. Quest'ultimo è anche un sito della rete atmosferica dell'infrastruttura di ricerca europea ICOS (Integrated Carbon Observation System) dedicata allo studio del ciclo del carbonio e, grazie alla collaborazione con l'Università degli Studi di Urbino, è inserito nella rete globale AGAGE (Advanced Global Atmospheric Gases Experiment). Dopo avere sommariamente descritto il sito di misura ed i programmi di osservazione, presenteremo e discuteremo alcuni casi scientifici di utilizzo delle osservazioni al fine dello studio della variabilità dei gas serra su breve e lungo periodo ed al fine dello studio delle emissioni in atmosfera.

Comunicazioni

● **The Naples national facility for aerosol remote sensing of the ACTRIS research infrastructure.**

Manzo M. (1), Boselli A. (2), Damiano R. (1), Sannino A. (1), Spinosa S. (1), Amoruso S. (1)
(1) *Università degli Studi di Napoli "Federico II", Dipartimento di Fisica "Ettore Pancini"*
(2) *Consiglio Nazionale delle Ricerche-Istituto di Metodologie per l'Analisi Ambientale, CNR-IMAA*

The Naples facility is part of the European Research Infrastructure ACTRIS —Aerosol Cloud and Trace Gases Research Infrastructure— and in the international networks EARLINET and AERONET. Its main objective is the characterization of atmospheric aerosol and the study of its influence on the environment, climate, and atmospheric physics, using remote sensing instrumentations and *in situ* monitoring techniques. The main techniques are based on the interaction of optical radiation with atmospheric constituents, as lidar and sunphotometer. These techniques are complemented by various support diagnostics such as meteorological probes, optical particle counter, etc. In this communication we will report on the recent refurbishment of the Naples facility in the frame of PON project PER-ACTRIS-IT, that allowed the upgrade of the MALIA and HSRL lidar systems, the acquisition of a transportable lidar and a mobile unit useful for measurement campaigns on the territory. Besides these, the ACTRIS National facility in Naples is further equipped with two sunphotometers and two lidars measuring wind profiles, making it a very useful observation site for aerosol monitoring in the Mediterranean area.

The Italian Lidar Ceilometer Network-ALICENET: Retrievals and long-term analyses of aerosol vertical profiles across Italy.

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([3]) *Agenzia Regionale della Protezione dell'Ambiente della Valle d'Aosta, ARPA VdA, Italia*

ALICENET is the Italian network of Automated Lidar-Ceilometers (ALCs) using remote sensing to monitor 24/7 aerosol vertical profiles and clouds (up to 15 km with a resolution of 15 m) across the country. It is a growing consortium network coordinated by CNR-ISAC, involving different institutions and contributing to the E-PROFILE EUMETNET program. The network, extending from the North to the South of Italy, covers a wide range of atmospheric and environmental conditions within the Mediterranean area. The ALC data processing is centralized at CNR-ISAC and allows inferring quantitative and vertically resolved information on aerosol properties (*e.g.*, aerosol extinction, mass, stratification). In this communication, a fully re-processed multi-year ALC dataset of five ALICENET stations (Aosta, in the Alps; Milan and San Pietro Capofiume, within the Po Valley; Rome, the main urban site in Central Italy; Messina, a maritime site in Sicily) is analyzed in synergy with *in situ* meteorological and chemical measurements, model reanalyses and air mass trajectories. The results are presented focusing on the long-term characterisation of aerosol vertical profiles and main transport dynamics across Italy.

Analisi dello scostamento tra i valori di riferimento dei coefficienti di estinzione e di backscattering misurati nella periferia di Roma e i valori di riferimento in ambiente urbano presenti in letteratura.

Rutigliano N., Di Giovanni D., Martellucci L., Puleio A., Rossi R., Gaudio P.

Dipartimento di Ingegneria Industriale, Università degli Studi di Roma "Tor Vergata", Italia

Il lidar in applicazioni orizzontali è uno strumento di monitoraggio ambientale molto sensibile, ma incapace di determinare la causa della variazione di densità atmosferica locale osservata e di fornire una misura assoluta della stessa conferendogli bassa specificità. Per valutare le variazioni delle proprietà ottiche, e, di conseguenza, della concentrazione atmosferica, è necessario utilizzare degli algoritmi di inversione dell'equazione lidar. Data la natura della stessa, per operare l'inversione è necessario conoscere un valore di riferimento per i coefficienti di estinzione e di backscattering. Storicamente questi valori di riferimento sono stati misurati, assunti costanti in troposfera a parità di temperatura, umidità relativa e tipologia di ambiente (urbano, rurale e marittimo), da Shettle e Fenn nel 1979. Considerando il cambiamento degli ambienti urbani da allora, è stato sviluppato un modello numerico che, da misure condotte presso il Dipartimento di Ingegneria Industriale dell'Università degli Studi di Roma "Tor Vergata", fornisce nuovi valori di riferimento per l'inversione in ambienti urbani simili a quelli della periferia romana.

Stima delle principali sorgenti emissive di particolato atmosferico ed analisi della variabilità stagionale e diurna per le città di Milano e Bologna.

Magnani C. ([1]), Renzi L. ([1]), Paglione M. ([1]), Rinaldi M. ([1]), Zannoni N. ([1]), Orsini D. ([1]), Petit JE. ([2]), Timonen H. ([3]), Calzolari F. ([1]), Marinoni A. ([1])

([1]) *ISAC-CNR, CNR Area Territoriale di Ricerca di Bologna, Bologna, Italia*

([2]) *Laboratoire des Sciences du Climat et de l'Environnement, CEA-CNRS-UVSQ-Paris Saclay, UMR 8212, CE de Saclay, Gif-sur-Yvette, France*

([3]) *Atmospheric Composition Research, Finnish Meteorological Institute, Helsinki, Finland*

Le politiche europee per la mitigazione dell'inquinamento atmosferico hanno prodotto significative diminuzioni degli inquinanti in modo non omogeneo tra le diverse specie, alcune delle quali spesso rimangono superiori alle soglie fissate per la qualità dell'aria e della salute. Il progetto RI-URBANS sfrutta l'esperienza avanzata delle infrastrutture di ricerca, al servizio delle agenzie locali per la qualità dell'aria, in 9 città europee in cui sono condotte osservazioni coordinate di composizione chimica. Misure innovative di aerosol non refrattario tramite spettrometro di massa Tof-ACSM e misure di concentrazione di black carbon derivate da tecniche ottiche (AE33, 7λ), consentono, grazie ad avanzata analisi statistica, il monitoraggio continuo ad elevata risoluzione temporale delle diverse sorgenti di emissione. L'analisi tramite Positive Matrix Factorization e l'applicazione di un modello per il Source Apportionment del black carbon viene condotta da ogni città e confrontata con i tool del progetto. In questo lavoro saranno presentati i primi risultati che includono la variabilità stagionale e diurna delle principali sorgenti nelle città italiane afferenti a RI-URBANS.

Characterization of high-altitude fire smoke layers due to Canadian wildfires crossing the urban area of Naples (Italy).

Damiano R. ([1]), Amoruso S. ([1]), Manzo M. ([1]), Sannino A. ([1]), Spinosa S. ([1]), Boselli A. ([2])
([1]) *Università degli Studi di Napoli "Federico II", Dipartimento di Fisica "Ettore Pancini"*
([2]) *Consiglio Nazionale delle Ricerche-Istituto di Metodologie per l'Analisi Ambientale, CNR-IMAA*

In the summer of 2017 huge wildfires occurred in British Columbia (Canada), leading to the injection of an unusually high concentration of biomass burning aerosol in the atmosphere. An uncommon load of smoke ensued in the upper troposphere and lower stratosphere in August 2017, which crossed the European area at altitudes between 3–18 km in the following weeks. Smoke particles that were transported across the Atlantic Ocean towards Europe at high altitudes (12 km) were observed over Naples using both active and passive remote sensing instruments, operational at University of Naples Federico II. In this communication we will report on the optical and microphysical properties of the aged biomass burning aerosol. These properties were characterised both along the atmospheric profile by means of a multi-wavelength elastic-Raman lidar device and integrated over the atmospheric column by a sun-sky-lunar photometer operating within the AERONET global network. The features of the aerosol originating from the Canadian wildfires will be compared to those resulting from fresh biomass burning aerosol ensuing huge multiple fires occurred in July 2017 on the Mount Vesuvius near Naples.

An innovative system for the simultaneous acquisition of analog and photon counting lidar signals.

Spinosa S. ([1]), Amoruso S. ([1]), Damiano R. ([1]), Di Donfrancesco G. ([2]), Manzo M. ([1]), Sannino A. ([1]), Boselli A. ([3])
([1]) *Università degli Studi di Napoli "Federico II", Dipartimento di Fisica "Ettore Pancini"*
([2]) *ALA, Advanced Lidar Applications s.r.l., Napoli*
([3]) *Consiglio Nazionale delle Ricerche-Istituto di Metodologie per l'Analisi Ambientale, CNR-IMAA*

The study of the electronics related to the acquisition of the detected signals plays an important role for the improvement of Lidar systems for atmospheric remote sensing. The spanning of the atmospheric Lidar echo signals over many decades often obliges the simultaneous use of both analog and photon counting detection during the same measurement. Thanks to the new possibilities offered by FPGA (Field Programmable Gate Array) electronics and the ever-increasing efficiency of DSP (digital signal processing) processors, both

detection scheme can now be realized on a single electronic board able to manage even more sources simultaneously. Here, an acquisition board will be described that includes up to 5 channels simultaneously acquirable in photon counting and analog modes. This board is also able to avail itself as one of the most recent and fast data processing, storage, and communication methods, which makes it completely independent of the PCs or rack mount devices necessary to control classic type instrumentation. Experimental results obtained with this acquisition board on the Lidar systems operating at the University of Naples Federico II will be illustrated and discussed.

New measurements of full-spectrum light absorption on carbonaceous aerosol and mineral dust.

Isolabella T. ([1])([2]), Bernardoni V. ([3]), Abd El E. ([1])([1]), Brunoldi M. ([1]), Massabò D. ([1])([2]), Mazzei F. ([1])([2]), Vernocchi V. ([2]), Prati P. ([1])([2])
([1]) *Dipartimento di Fisica, Università di Genova*
([2]) *INFN, Sezione di Genova*
([3]) *Dipartimento di Fisica, Università di Milano e INFN, Sezione di Milano,*

Particulate matter (PM) has a detrimental impact on health, air quality and climate change. Several of the compounds that make up PM play a major role in the Earth's energy balance by absorbing and scattering solar radiation. Among them, carbonaceous aerosols (CA) are the strongest light-absorbing class of PM. Mineral dust (MD) also exhibits selective light-absorption characteristics in certain bands of the solar radiation spectrum. In order to develop efficient strategies for mitigation of climate change, it is necessary to understand the impact that each of the different PM components have. Optical analysis of PM is the starting point for component and source apportionment of atmospheric aerosol. By exploiting the different spectral behaviour of different PM components, it is possible to infer the composition of the aerosol and its sources. A new instrument for white-light absorption measurements of aerosol has been assembled and validated at the University of Genoa. In this communication an overview of the instrument will be given, alongside a presentation of analysis results of several samples of CA and MD, highlighting the potential of the broad-spectrum light absorption analysis.

Analisi temporale e spaziale delle concentrazioni di CO_2 sull'Italia mediante dati satellitari.

Romaniello V., Spinetti C., Piscini A.
Istituto Nazionale di Geofisica e Vulcanologia

L'anidride carbonica è un gas ad effetto serra immesso in atmosfera da sorgenti legate sia a cicli naturali che ad attività antropiche. In questo lavoro, vengono analizzati i dati acquisiti dalla missione spaziale Orbiting Carbon Observatory 2 (OCO-2) della NASA. Sono stati analizzati 8 anni di acquisizioni sull'intero territorio italiano al fine di valutare la variabilità sia temporale sia spaziale della concentrazione di CO_2. È stato così calcolato un incremento di circa 21 ppm nel periodo 2015–2022 con un tasso di crescita di circa 6 ppm/anno tra il 2019 e il 2020 ed un ritorno a valori medi di circa 3 ppm/anno dopo la pandemia COVID19. Questi risultati sono stati confrontati e validati con i dati CAMS-ECMWF. Le serie temporali delle concentrazioni sono state infine utilizzate per effettuare un'analisi spaziale delle aree caratterizzate da minori/maggiori concentrazioni di CO_2 per individuare assorbimenti/sorgenti sul territorio, in relazione con tutta probabilità all'utilizzo del suolo. L'analisi rivela che le regioni del nord Italia, con più popolazione e industrie, sono sorgenti di CO_2 mentre si conferma il ruolo fondamentale della vegetazione nell'assorbimento del gas.

Retrieving pollution from photovoltaic solar panels.
Lolli S.
CNR-IMAA
The study presents the results of using photovoltaic systems, commonly installed on buildings to produce energy, to detect episodes of air pollution. The amount of electric power produced by the panels is affected by various factors, including the solar panel efficiency, technical characteristics, and atmospheric constituents like aerosols that can scatter and absorb incoming solar radiation. The retrieved Aerosol Optical Depth (AOD) is used to evaluate the concentration of surface particulate matter and atmospheric column turbidity, which affects the solar panel energy production. The abstract presents a new technique to retrieve the AOD at 550 nm through an iterative process and forecast the produced electric energy by a photovoltaic panel using a simple model.

30 years of observations of the ozone density vertical profiles at Osservatorio Atmosferico of CETEMPS/DSFC/UNIVAQ in L'Aquila (Italy).
Rizi V., Iarlori M., Lidori R., Di Fabio S., Balotti A., Avocone E.
CETEMPS/DSFC/Università degli Studi dell'Aquila, L'Aquila, Italy
This contribution is devoted to the presentation of the multi-annual database of stratospheric ozone density vertical profiles as measured almost continuously at CETEMPS starting since 1991. The measurements were done with a DIfferential Absorption Lidar (DIAL) in the period between 1991 and 1999, and mainly with Electro Chemical Cell (ECC) ozone-sondes flying with meteorological balloons (1994–present). The presentation also includes and discusses some results concerning the trends of the ozone concentrations in troposphere and stratosphere.

Discussing the effect of sampling error on the estimation of ozone variability and trend in UT/LS.
Marra F. ([1]), Kreher K. ([2]), Madonna F. ([1])([3])
([1]) *Consiglio Nazionale delle Ricerche-Istituto di Metodologie per l'Analisi Ambientale, CNR-IMAA, Tito Scalo, PZ, Italy*
([2]) *BK Scientific GmbH, Mainz, Germany, BKS, Germany*
([3]) *Dipartimento di Fisica "E.R. Caianiello", Università degli Studi di Salerno, Italy*
The study of ozone in the upper troposphere/lower stratosphere (UT/LS) and of its correlation with temperature is one of the key components for the study of climate change. Various studies have estimated trends both regionally and globally in the UT/LS, using both satellite and ground-based data and different measurements techniques. However, the measurement quality and coverage, in time and space, may significantly affect the estimated trends. This communication discusses the impact of the sampling frequency, estimating its error at different latitudes and vertical layers in the UT/LS, on the estimation of the ozone inter-annual variability and on the trends in the period 1978–2022, using a merged dataset combining the ozone soundings provided by SHADOZ (Southern Hemisphere ADditional OZonesondes), NDACC (Network for the Detection of Atmospheric Composition Change) and WOUDC (World Ozone and Ultraviolet Radiation Data Centre). The available measures are clustered into three groups based on the temporal gaps of the historical time series, providing criteria for selecting the best data for climate studies.

Aula F7 - Giovanna Mayr **ore 16:15 – 19:30**

Sezione V

Biofisica e fisica medica

Presiede: Mariani P. (Università Politecnica delle Marche)

Relazioni su invito

▲ **Dynamic and structural insights into Cysteine Synthase complex as a tool for the development of new antibiotic adjuvants.**

Marchetti M.

Dipartimento di Medicina e Chirurgia, Università di Parma, Italia

Cysteine biosynthesis is intimately connected to bacterial viability and redox homeostasis. The last two enzymes of the pathway, absent in mammals, are serine acetyltransferase (SAT) and O-acetylserine sulfhydrylase (OASS), forming the Cysteine Synthase complex (CSC) which finely regulates both enzyme activities. Cysteine metabolism perturbation can boost bacterial susceptibility to oxidative stress damage, making SAT and OASS promising targets for antibiotic adjuvants. We investigated the dynamic and structural details of CSC formation by surface plasmon resonance (SPR), small-angle X-ray scattering (SAXS) and hydrogen-deuterium exchange mass spectrometry (HDX-MS). SAXS and HDX-MS results undisclosed the CSC assembly and the OASS and SAT conformational dynamics driving its formation. These structural data were exploited to run virtual screening campaigns. Compound series were synthesized and their binding and inhibitory effects were tested by fluorescence and UV-visible spectroscopy. The most potent OASS inhibitor developed so far, U415, was shown to destabilize CSC *in vitro*. The insights gained into CSC formation and dynamics would help the design of novel effective compounds.

▲ **Metodi biofisici per indagare processi molecolari coinvolti nel morbo di Alzheimer.**

Ortore M.G. ([1]), Vilasi S. ([2]), Spinozzi F. ([1]), Mariani P. ([1])

([1]) *Dipartimento di Scienze della Vita e dell'Ambiente, Università Politecnica delle Marche, Ancona, Italia*

([2]) *Istituto di Biofisica, CNR, Palermo, Italia*

Lo studio dell'aggregazione di proteine in forma di fibre amiloidi ha coinvolto una notevole parte della comunità scientifica negli ultimi decenni. L'ipotesi della cascata amiloide, legata al morbo di Alzheimer, ci ha indotti a credere che trovare molecole, naturali o sintetiche, che potessero interferire con questo processo, potesse portare ad una cura per questa terribile patologia. In questo intervento parlerò dei risultati più importanti raggiunti in questo ambito grazie ad approcci biofisici che utilizzano tecniche di diffusione di raggi X a piccolo angolo mediante luce di sincrotrone: dal monitoraggio temporale dell'aggregazione con una risoluzione al millisecondo, all'utilizzo di molecole ingegnerizzate per penetrare nella barriera ematoencefalica, sino alla determinazione della risposta dinamica di membrane modello all'azione di chaperonine abili a reclutare oligomeri tossici. La caratterizzazione biofisica di questi processi si lega oggi anche allo sfruttamento di altre potenzialità delle fibre amiloidi, quali possibili sistemi per la sensoristica e il drug-delivery.

▲ **Structural heterogeneity of the tumor suppressor p53 as monitored by static and time-resolved fluorescence combined with computational approaches.**

Bizzarri A.R.
Biophysics and Nanoscience Centre, Dipartimento di Ecologia e Biologia (^{DEB}) , Università della Tuscia, Viterbo, Italia

The tumor suppressor p53 protein belongs to the class of intrinsically disordered proteins, characterized by a partial structural disorder. p53 plays a crucial role in several biological functions, such as cell cycle progression, apoptosis and DNA repair. For its prominent biological role, p53 is an intriguing example of IDPs whose understanding deserves a large interest from both the biological and physical point of view. The DNA-binding domain (DBD) of p53 at different temperatures and upon binding to the anticancer peptide p28 was investigated by static and time-resolved fluorescence combined with computational approaches. The fluorescence emission decay of the lone Trp residue of DBD-p53 was described by a stretched exponential function which was put into relationship to a structural disorder in the Trp environment and then to the co-existence of sligthly different conformations. Such a structural heterogeneity was found to be affected by both temperature changes and binding to p28. The modulation of the p53 conformational heterogeneity as induced by point mutations was also investigated. All these results were discussed in connection with the functional role of p53.

Comunicazioni

● **Multivariate Curve Resolution Alternating Least Squares (MCR-ALS) applied to Raman MicroSpectroscopy: an innovative tool to derive cellular responses to chemotherapy drugs.**

Notarstefano V. ([1]), Byrne H.J. ([2]), Ortore M.G. ([1]), Spinozzi F. ([1]), Mariani P. ([1])
([1]) *Dipartimento di Scienze della Vita e dell'Ambiente, Università Politecnica delle Marche, Italia*
([2]) *FOCAS Research Institute, Technological University Dublin, City Campus, Ireland*

Raman MicroSpectroscopy (RMS) is a powerful label-free tool to probe biological systems at a molecular level. The application of the innovative chemometric approach named MCR-ALS to Raman data provides kinetic information on cellular processes. Here, this approach was used to explore the mode of action of three nuclear targeting drugs, cisplatin (1,2), 5-fluorouracil (1), and 5-azacytidine (3), at a cellular level. MCR-ALS was used to decompose the cell spectral profiles, and to correlate the progression of cells from viable to dead with the action of the drugs. As a result, we evidenced a correlation between the time dependence of the spectral profiles and the cell healthy state (viable, early apoptotic, late apoptotic/dead cells). Moreover, the comparison by Principal Component Analysis of the spectral profiles of viable cells exposed to the three different drugs, indicated a different initial mode of action and different cell death pathways.

● **Hemoglobin: a tale of allosteric serendipity.**

Ronda L. ([1])([2])([3]), Buoli Comani V. ([4]), Campanini B. ([3])([4]), Cozzi M. ([1]), De Bei O. ([3]), Faggiano S. ([2])([4]), Failla M. ([5]), Giaccari R. ([4]), Gianquinto E. ([5]), Kovachka S. ([5]), Lazzarato L. ([5]), Marchesani F. ([4]), Marchetti M. ([1]), Spyrakis F. ([5]), Bettati S. ([1])([2])([3])
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([4]) *Dept. of Food and Drug Science, University of Parma, Parma, Italy*
([5]) *Dept. of Drug Science and Technology, University of Turin, Turin, Italy*
In recent years, we repurposed the 30-year experience of our group in hemoglobin (Hb) structure and function characterization by targeting its interaction with bacterial hemophore proteins in the quest for innovative antimicrobial strategies. A virtual screening and molecular docking campaign led to the identification of a set of potential inhibitors of Hb:hemophore interactions, that we experimentally tested by ELISA and STD-NMR. X-ray crystallography of the Hb complex with the most promising inhibitor showed that it binds the Hb tetramer at multiple sites, bridging the two alpha- and the two beta-chains, suggesting an effect on Hb oxygen binding properties. Indeed, the ligand causes a ten-fold increase in oxygen affinity and a drop in binding cooperativity, consistent with the stabilization of a high-affinity, relaxed conformation. The exciting conclusion is that this molecule could be a starting point both for a bacteriostatic approach, through the inhibition of protein-protein interactions essential for bacterial iron supply, and, through its allosteric effects, for the treatment of diseases that would benefit from a left-shift of Hb oxygen binding curve.

Protein co-aggregation in systemic amyloidosis studied by isotope-edited infrared spectroscopy.

Natalello A. ([1]), Ami D. ([1]), Terrones Palmer M. ([1]), Giorgetti S. ([2]), Lavatelli F. ([2]), Raimondi S. ([2]), Marchese L. ([2])
([1]) *Università di Milano-Bicocca, Dipartimento di Biotecnologie e Bioscienze, Milano*
([2]) *Università di Pavia, Dipartimento di Medicina Molecolare, Istituto di Biochimica "A. Castellani", Pavia, Italy*
The aggregation of specific proteins is involved in many diseases, from neurodegenerative disorders to systemic amyloidosis. Increasing evidences from *in situ* characterizations have pointed out to the crucial role of protein co-aggregation and heterotypic interactions in *in vivo* aggregation. However, it is very difficult to obtain information on misfolding and aggregation of each protein when more protein variants are co-present in the same mixture. To address this point, an isotope-edited Fourier transform infrared (FTIR) spectroscopy approach will be presented. Since the amide I band in the FTIR spectrum occurs in a different spectral range for ^{13}C labeled and unlabeled (^{12}C) proteins, the secondary structures (native and β-sheet in aggregates) of each species can be monitored when labelled and unlabelled molecules are co-present in a mixture. Not only the misfolding and aggregation of each protein can be monitored independently but also the formation of mixed β and unmixed β-sheets can be evaluated. The isotope-edited FTIR approach will be illustrated on relevant systems, as the amyloid-like/amorphous aggregation and co-aggregation of proteins involved in systemic amyloidosis.

A biophysical approach to study an orphan disease: the case of CblC, a rare disorder of vitamin B12 intracellular metabolism.

Vilasi S. ([1]), Longo L. ([1])([3]), Randazzo L. ([1]), Bollati M. ([1]), Carrotta R. ([1]), Costa M.A. ([1]), De Rosa M. ([1]), Mangione M.R. ([1]), Martorana V. ([1]), Milani M. ([1]), Ortore M.G. ([2]), Passantino R. ([1])
([1]) *Biophysics Institute, National Research Council*
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([3]) *Department of Biological, Chemical and Pharmaceutical Sciences and Technologies, University of Palermo, Palermo, Italy*
The cblC disease is an inborn disorder of the vitamin B12 (cobalamin, Cbl) metabolism. The affected children manifest devastating symptoms involving vision, growth, and learning. The illness is caused by mutations in the gene codifying for MMACHC, a protein that transports

and transforms the different Cbl forms. Although the crystal structure of the wild-type (WT) protein is available, a systematic study on the effect of each specific mutation on the resulting protein is still lacking. Here we present data on the biophysical characterization of WT MMACHC, and two variants resulting from CblC pathological mutations. By using a biophysical approach including spectroscopy, Dynamic-Static Light and Small X-Ray Angle Scattering, and Molecular Dynamics, we investigated protein structure/stability and ability to bind and transform Cbl. Moreover, we evaluated whether drug-like molecules identified by computational methods, or non-specific stabilizers (osmolytes) could restore functionality in MMACHC mutants. Overall our results reveal how a biophysical approach can offer new insights in the study of CblC mutations' specific effect and help prospecting new routes for the CblC treatment.

Multiple interacting collective modes in proteins.

Conti Nibali V. ([1]), Sacchetti F. ([2]), Paciaroni A. ([2]), Petrillo C. ([2]), Wanderlingh U. ([1]), D'Angelo G. ([1])

([1]) *Università degli Studi di Messina*

([2]) *Università degli Studi di Perugia*

An in-depth knowledge of protein dynamics is essential to comprehend their functionality. Among the wide range of motions —from the femtoseconds to seconds time scale— that proteins sustain, the term "protein collective dynamics" refers to the intricate patterns of coordinated motions of a large fraction of atoms in the sub-picosecond time scale, which are hypothesized to be involved in functional dynamical mechanisms. Here, we have investigated the longitudinal and transverse collective dynamics of a globular protein by means of a combined computational and experimental approach, exploiting classical molecular dynamics simulations, Brillouin neutron scattering, inelastic X-ray scattering and Raman spectroscopy. This approach allows for a comprehensive and unprecedented picture of the collective dynamics of the investigated protein, a behavior likely to be encountered for all globular proteins. We provide an interpretation of the observed collective dynamical behavior, by means of a correlation to the structure of the studied protein and an evaluation of the origin of the excitations. The present findings provide a perspective for describing energy-transfer mechanisms in proteins.

Confronto di spettri vibrazionali di linee cellulari per individuare marcatori spettrali di patologia.

Perna G., Lasalvia M., Capozzi V.

Dipartimento di Medicina Clinica e Sperimentale, Università di Foggia, Foggia, Italy

Da diversi anni tecniche vibrazionali, come le spettroscopie Raman e FTIR, sono utilizzate per indagare cellule caratterizzate da diverse patologie, con risultanti promettenti nella prospettiva di utilizzo in ambito clinico per scopi diagnostici. Nella maggior parte dei casi l'interpretazione dei risultati richiede l'utilizzo di tecniche di analisi multivariata. In particolare, l'analisi del discriminante lineare applicato alle componenti principali (PCA-LDA) ed ai minimi quadrati parziali (PLS-DA) sono due modelli di classificazione utilizzabili a tal fine. Pertanto, abbiamo misurato set di spettri Raman e FTIR di varie linee cellulari del seno e del colon, sia sane che cancerose, per valutare le performance di classificazione di tali tecniche multivariate. I modelli di classificazione sono stati in grado di discriminare spettri da diversi tipi di cellule con accuratezza tra il 93% e il 100%, sensibilità tra l'86% e il 100% e specificità tra il 90% e 100%. Quindi, anche considerando che le cellule possono essere cresciute su vetrini economici e standard, questo studio conferma che la spettroscopia vibrazionale ha un notevole potenziale per stabilire modelli diagnostici affidabili.

Progetto Hadron Beam for Radio-Modulation Study (HaBraMs)

Porzio G. ([1])([2]), Bagnale L. ([1])([2]), Buompane R. ([1])([2]), Manti L. ([2])([3]), Pacifico S. ([4]), Formato M. ([4]), Bortolussi S. ([5])([6]), Gialanella L. ([1])([2])

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Lo studio della dosimetria *in vitro* è alla base dello sviluppo di nuove tecniche di radioterapia oncologica di precisione e dello studio di nuovi composti farmaceutici potenzialmente radiomodulanti. L'Università della Campania "L. Vanvitelli" ha di recente finanziato il progetto Hadron Beams for Radio-Modulation Study (HaBraMs) che prevede la conduzione di una serie di esperimenti con fasci adronici prodotti con l'acceleratore Tandem da 3 MeV del laboratorio CIRCE-DMF, sulle cellule sane e tumorali, al fine di indagarne il danno subito. È previsa, inoltre, la costruzione di un laboratorio di Biofisica per la gestione dei campioni pre- e post-irraggiamento. Il focus del progetto è lo studio delle proprietà radiomodulanti dei polifenoli delle foglie d'uva (GLP) che saranno studiate per il loro possibile utilizzo nella radioterapia oncologica (RT) come radioprotettori dei tessuti sani e radiosensibilizzatori dei tumori refrattari. Attualmente, si stanno eseguendo i primi test del setup di irraggiamento con fasci di protoni e alfa e misure dosimetriche con rivelatori CR39. Verranno presentati il nuovo laboratorio di Biofisica, il setup di irraggiamento e i primi risultati.

Aula F5 - Hildred Blewett **ore 16:15 – 19:30**

Sezione VI
Fisica applicata, acceleratori e beni culturali
Presiede: Curcio A. (INFN, Laboratori Nazionali di Frascati)

Relazioni su invito

▲ **The IRIS Salerno infrastructure for superconducting green line.**
Avallone G. ([1])([2]), De Pasquale S. ([1])([2]), D'Agostino D. ([2]), Gambardella U. ([2]), Leo E. ([2]), Saggese A. ([1])([2]), Severino C. ([2]), Severino F. ([2])
([1]) *Dipartimento di Fisica, Università degli Studi di Salerno, Fisciano, Italia*
([2]) *INFN, Sezione di Napoli, Gruppo Collegato di Salerno, Fisciano, Italia*
The capability of managing superconducting devices for societal as well as for research large applications is tightly connected to the availability of cryogenic infrastructures and competencies. Furthermore, in our era, it is of considerable importance to satisfy the demand for new innovative green technologies. Within the Innovative Research Infrastructure on Applied Superconductivity (IRIS) program in the Salerno area, made of University, INFN and CNR-SPIN people, we take the responsibility to install a new test facility able to test superconducting high-voltage DC power transmission line (up to 1 GW), and in general to integrate the capabilities of the national network in the field of superconducting magnets. The new infrastructure, hosted in the University of Salerno campus, will be close to the other infrastructure (THOR laboratory) recently set for the GSI/FAIR support. Moreover, this activity is not an extension of the existing laboratory but a new dedicated facility which falls in the new green line energy, one of the most promising societal applications of superconductivity. Finally, this area could also become a cryogenic reference facility in the South of Italy.

▲ **L'impatto della fisica fondamentale sulla società attraverso gli strumenti del Trasferimento Tecnologico: Modelli e storie di successo dell'INFN.**
Cestelli Guidi M.
INFN, Laboratori Nazionali di Frascati, Frascati, RM
I grandi esperimenti pensati e realizzati per rispondere alle domande della fisica fondamentale contengono un elevatissimo livello di tecnologia di frontiera. Una delle sfide a cui ci troviamo oggi a rispondere, accanto a quella di far avanzare la conoscenza, è quella di portare queste tecnologie fuori dall'ambito del mondo della ricerca affinché il beneficio sulla società si traduca anche in termini di crescita competitiva del paese. Questa è la materia di cui si occupa il Trasferimento Tecnologico, inteso come l'insieme delle procedure e degli strumenti necessari per facilitare e catalizzare questi processi che guidano lo scambio di conoscenza fra il mondo della ricerca e la società, sia essa intesa come il mondo delle imprese che un qualunque contesto che possa essere destinatario delle applicazioni, consentendo così alle nuove tecnologie di tradursi in beni e servizi fruibili dalla collettività.

▲ **High-performance computing for physics application.**
Donvito G.
INFN, Sezione di Bari
In this communication we will describe new computing technologies, R&D activities and newly available solutions that are currently used to improve speed and performance of data

analytics and processing. We will discuss how the evolution of those technologies could be a path toward the solution of future challenging problems in scientific computing. We will then report about the R&D activities on which INFN is focusing its effort, with particular reference to the development and implementation of a distributed "data lake", a distributed, nation-wide infrastructure that leverages modern cloud computing techniques to provide seamless access to heterogeneous computing and storage resources.

Comunicazioni

Voltage taps placement on HTS tapes for NZPV measurements.

Saggese A. ([1])([2]), Iannone G. ([2]), Gambardella U. ([2])
([1]) *Dipartimento di Fisica, Università di Salerno, Fisciano, Italia*
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The Normal Zone Propagation Velocity NZPV is an important tool for the protection against destructive quenches. The most used method for measuring this velocity is based on the measure of the voltage rise on adjacent voltage taps placed along a superconducting tape after the generation of a hot spot on a well-known position on the tape. The chosen apparatus as well as the placement of the voltage tap may affect the measured NZPV. In fact, the values obtained with voltage taps too close to the hot spot will be influenced by the local heat. Conversely, voltage taps placed too far may be useless because they would never be reached by the normal zone propagation prior to the overheating and perhaps the permanent damage of the tape. Between these two constraints, all voltage taps may be satisfying being placed by balancing the number and the width of voltage taps. A model based on the analysis of preliminary quench measures yields a clear indication of the optimal length upon which the voltage taps may be placed. The model yields the computation of a specific parameter that characterizes the experimental apparatus and guides further modification toward the investigation range of interest.

First steps of the THOR test facility for accelerator magnets.

Leo E. ([1])([2]), Avallone G. ([1])([2]), D'Agostino D. ([2]), Ferrentino A. ([1])([2]), Gambardella U. ([2]), Iannone G. ([2]), Saggese A. ([1])([2]), Severino C. ([2]), Severino F. ([2])
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Particle accelerators use several magnetic modules arranged on a ring for both bending and focusing particles beam. As a good practice magnetic modules must be individually tested under working conditions. For this purpose, GSI has commissioned the final tests of their superconducting quadrupole modules prior to the installation in the SIS100 accelerator in Darmstadt. In order to answer these needs, at INFN Gruppo Collegato di Salerno the Test in Horizontal (THOR) laboratory has been created. This facility is equipped with a Linde cryogenic refrigerator able to deliver a maximum flow of 15 g/s of supercritical He with an isobaric power of 200 W @ 4.5 K without pre-cooling. Superconducting coils may be biased with a 20 kA Danfysik or a 400 A Cryogenics bipolar power supplies, both equipped with fast early quench detectors. Vacuum and cryogenic tools are used for ensuring the needed insulation vacuum and UHV beam pipe. In the laboratory, we developed instruments to carry out the quality assurance tests (leak tests, insulation tests, and power tests).

Coil realization, insulation, and heat-treatment process study for validating Bi-2212 Rutherford cable dipole insert design at Fermilab.

D'Agliano A., Donati S., Giusti V., Novitski I., Zlobin A.V., Turrioni D., Barzi E.

Pisa University e INFN, Sezione di Pisa
One of the four main goals of the U.S. Magnet Development Program (US-MDP) is to develop and demonstrate the functioning of a hybrid LTS/HTS accelerator magnet generating fields beyond 16 T. For this purpose, R&D efforts are to enhance High-Temperature Superconductor (HTS) characteristics, considering $Bi_2Sr_2CaCu_2O_{8-x}$ (Bi-2212) as a conductor element. This communication examined the technology for a state-of-the-art realization of the Bi-2212 cosine-theta coil allocated in the 3D-printed Inconel alloy mandrel. We deformed the 1.4 mm width Rutherford cable reproducing coil geometry and we realized its insulation by braiding the sample with ceramic materials soaked in TiO_2 slurry. Eventually, we replicated the heat treatment using a high-temperature furnace at atmospheric pressure and 50 bar in an oxygen/argon environment. Post-reaction visual analysis of the sample is collected and exposed. Fundamental aspects of magnet design and technology were studied, validating the geometry and process design of the Bi-2212 insert. The first LTS/HTS cosine theta hybrid magnet will be assembled at the end of September 2023 and then tested in the Fermilab cryogenic test facility at the end of this year.

Experimental and numerical investigation of the flux-jump influence on the screening properties of MgB_2 magnetic shields.

Fracasso M. ([1])([2]), Gerbaldo R. ([1])([2]), Ghigo G. ([1])([2]), Laviano F. ([1])([2]), Sparacio S. ([1])([2]), Torsello D. ([1])([2]), Solovyov M. ([3]), Gömöry F. ([3]), Grigoroscuta M.A. ([4]), Aldica G. ([4]), Burdusel M. ([4]), Badica P. ([4]), Gozzelino L. ([1])([2])
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([4]) *National Institute of Materials Physics, Magurele, Romania*
MgB_2 is one of the most promising materials for superconducting bulk applications, as, for instance, magnetic shielding. However, the occurrence of thermomagnetic instabilities, such as flux jumps, drastically deteriorates the intrinsic shielding properties of the superconductor making the prediction of these phenomena a strategic necessity. To this aim, starting from the experimental evidence of flux jump occurrence in both open and single capped MgB_2 tubes we developed a 2D axial-symmetric model coupling heat diffusion and magnetic equations. First, we validated the model successfully reproducing the experimental data at the operational temperatures of 20 K, 25 K, and 30 K. Then, focusing on the $T_{OP} = 30$ K, the evolution of the local magnetic field, temperature, and current density were correlated with the abrupt worsening of the shielding performance. Finally, the model was exploited to set up possible optimization routes to prevent the flux jump occurrence both improving the MgB_2 thermal conductivity and the thermal exchange between the shield and the cooling stage and studying the influence of the superimposition of a ferromagnetic shell.

Lo Specchio Lineare: Archimede ai tempi dell'IOT.

Palatiello M. ([1])([2]), Cobal M. ([1])([2]), Grassmann H. ([1])
([1]) *University of Udine*
([2]) *INFN, Sezione di Trieste e Gruppo Collegato di Udine*
Lo Specchio Lineare è stato ideato e sviluppato presso l'Università degli Studi di Udine grazie allo spin-off accademico Isomorph srl. L'idea si ispira al sistema di difesa contro le navi romane (specchi ustori) utilizzato da Archimede ben 2200 anni fa, durante l'assedio di Siracusa. L'apparato costruito, semplice ed economico (tutti gli specchi sono mossi solamente da tre piccoli motori ed il punto focale, dove risiede lo scambiatore, è fisso a terra) ha mostrato ottime performance e ci si è dedicati ad ottimizzare questa semplice e antica tecnologia per il futuro. Il successo dell'utilizzo delle fonti di energia rinnovabili risiede anche nella

possibilità di essere decentralizzate. Inoltre la tecnologia attuale consente tramite la rete l'interazione tra impianti anche completamente diversi, semplicemente sfruttando l'Internet Of Things (IOT). Abbiamo quindi realizzato il software di controllo dell'apparato utilizzando un PLC industriale a gestione remota, rendendolo parte dell'IOT. Verranno quindi mostrate le potenzialità di questo impianto solare termico, ed il funzionamento via video dell'intero sistema di specchi dotato di inseguitore solare.

Impatto della radioattività su qubit superconduttivi.

Irace A.
Dipartimento di Fisica, Università La Sapienza, Italia

I qubit superconduttivi sono la tecnologia più promettente per lo sviluppo di un processore quantistico funzionante. La caratteristica principale dei qubit superconduttivi è che il loro spettro di livelli energetici è determinato dai parametri degli elementi del circuito e quindi è configurabile con relativa facilità. Tuttavia, la comparsa di errori correlati in chip con molti qubit rappresenta una minaccia per la scalabilità di tali dispositivi; è stato dimostrato che uno dei fenomeni che porta a questi errori correlati è la radiazione ionizzante dovuta ai raggi cosmici e all'ambiente. In questo intervento discuto alcuni recenti risultati sperimentali nello sforzo di capire ed eventualmente mitigare gli effetti della radioattività sui qubit superconduttivi e migliorare le loro prestazioni per il calcolo e la rilevazione quantistica. In particolare, descrivo la caratterizzazione di un qubit all'interno dei Laboratori Nazionali del Gran Sasso in termini di un'analisi statistica del suo tempo di rilassamento: con e senza una protezione aggiuntiva di piombo e in presenza di una fonte radioattiva.

Analisi della determinazione della concentrazione di agenti da spettri grezzi mediante l'utilizzo di un algoritmo Physics-Informed Deep Learning non supervisionato.

Puleio A., Martellucci L., Rossi R., Rutigliano N., Wyss I., Gaudio P.
Dipartimento di Ingegneria Industriale, Università di Roma Tor Vergata, Italia

L'elaborazione di modelli di calibrazione per gli strumenti di misura rappresenta uno degli aspetti fondamentali nel processo di estrazione delle informazioni di interesse da dati grezzi. Ciò, di norma prevede l'esecuzione di una serie di esperimenti controllati atti a caratterizzare tali informazioni e, laddove tale approccio non sia possibile, il ricorso alla calibrazione mediante stime fisico-teoriche. Entrambi i criteri sfortunatamente, possono subire l'influenza di numerose variabili esterne (come ad esempio l'esperienza dell'operatore). L'avvento delle tecniche di Machine Learning può rivelarsi uno strumento alternativo rispetto alle metodiche di calibrazione attualmente in uso. In questa comunicazione, viene presentata l'applicazione di un algoritmo di "Physics-Informed Deep Learning" non supervisionato, basato su modelli teorici, per la determinazione delle concentrazioni di diversi agenti mediante l'analisi diretta degli spettri grezzi simulati numericamente.

The origin of discrepancies in commercial Y-90 vial's activity assessments explained by Monte Carlo simulations.

Auditore L. ([1])([2]), Pistone D. ([1])([2]), Italiano A. ([2])([3]), Amato E. ([1])([2])([4]), Gnesin S. ([5])
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The origin of discrepancies found in a multicentre study between PET/CT measured activity and vendor-calibrated activity for Y-90 glass and resin microspheres was investigated by means of Monte Carlo (MC) simulations. Three vial configurations, containing Y-90 chloride, Y-90 labelled glass and resin microspheres, were modelled by GAMOS and the electric current per unit activity (I) generated in an activity-meter was estimated. Internal Bremsstrahlung photons emitted together with β particles were included in this study. The electric currents obtained for Y-90 glass (I_{glass}) and resin (I_{resin}) microspheres were compared in terms of relative percent difference with respect to that of Y-90 chloride, $\epsilon_{glass} = (24.6 \pm 3.9)\%$, and $\epsilon_{resin} = (-15.0 \pm 2.2)\%$, respectively, and each other, $\delta = (46.5 \pm 1.9)\%$. Results are in very good agreement with the values reported in the aforementioned multicentre study. The results indicate that the different geometry of the commercial vials and the metrological approach adopted for activity-meter calibration with Y-90 chloride liquid source can explain the found discrepancies.

Rivelatori di singolo fotone basati su microstrisce superconduttive.

Ercolano P. ([1]), Bruscino C. ([1]), Salvoni D. ([2]), Zhang C. ([2]), Ejrnaes M. ([3]), Cirillo C. ([4]), Huang J. ([5]), Chianese F. ([6]), Li H. ([5]), You L. ([5]), Cassinese A. ([1])([7]), Attanasio C. ([8]), Parlato L. ([1])([3]), Pepe G. P. ([1])([3])

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([8]) *Dipartimento di Fisica "E.R. Caianiello", Università degli Studi di Salerno, Fisciano, Salerno, Italy*

Al giorno d'oggi le tecnologie basate su singoli fotoni sono essenziali in molteplici applicazioni, che vanno dalla comunicazione all'ottica quantistica. Tra i diversi dispositivi esistenti, i rivelatori di singolo fotone a nanostriscia superconduttiva in NbN hanno attratto l'interesse della comunità scientifica per le loro eccellenti prestazioni alla lunghezza d'onda di 1550 nm, esibendo un'efficienza quasi unitaria ($> 90\%$), un tempo di jitter dell'ordine dei picosecondi, e un impareggiabilmente basso tasso di conteggi di buio (< 1 cps). Tuttavia, hanno limitazioni in termini della massima lunghezza d'onda a cui sono sensibili e dell'area che sono in grado di ricoprire. Pertanto, negli ultimi anni, la ricerca è stata estesa ai rivelatori basati su microstrisce, più larghe e quindi capaci di ricoprire aree più vaste, realizzate in materiali che abbiano una minore gap superconduttiva e che quindi siano più sensibili a fotoni di grande lunghezza d'onda. In questo lavoro, abbiamo studiato le prestazioni sia di rivelatori convenzionali in NbN sia di quelli basati su microstrisce in materiali innovativi, come MoSi e NbRe.

Aula F2 - Ginestra Giovene Amaldi **ore 16:15 – 19:30**

Sezione VII
Didattica e storia della fisica
Presiede: Giliberti M.A.L. (Università di Milano)

Relazioni su invito

▲ **"Dire l'indicibile": speaking of quantum physics in the Second Quantum Revolution.**
Bondani M.
CNR, Istituto di Fotonica e Nanotecnologie, Como, Italia
The new quantum technologies born out of the Second Quantum Revolution offer a significant context for the study of quantum physics and, at the same time, are a provocation for addressing its conceptual, philosophical, and cultural aspects. In fact, the basic tools of quantum technologies, quantum superposition and entanglement, fall outside the understanding of the macroscopic world given by classical physics and have been and are still being debated from an epistemological point of view. In recent years, as part of various European, national, and local initiatives, we have approached the teaching of quantum physics with a new teaching approach that aims to provide at the same time a precise description of quantum phenomena through a simplified mathematical formalism, feasible application examples and experiments, and a discussion of the conceptual aspect of the theory. We have involved teachers in refresher courses, students in summer schools and PCTO pathways, and the citizenry in the activities of the Italian Quantum Weeks. Our approach has the advantage of increasing widespread awareness of the cultural and not just scientific and technical importance of quantum mechanics.

▲ **A teaching learning sequence on modelling surface phenomena in liquids.**
Battaglia O. R.
Dipartimento di Fisica e Chimica "Emilio Segrè", Università di Palermo, Palermo, Italia
Surface phenomena are relevant to many fields, such as physics, engineering, and medicine and are often studied only macroscopically. By thermodynamical approach or by introducing a force per unit length. The thermodynamic approach can supply an adequate description of surface phenomena, but it often turns out to be too abstract for secondary school students. The approach based on forces may be incoherent and pedagogically not successful. In this contribution, I discuss a structured Teaching/Learning Sequence on surface phenomena. The Teaching/Learning Sequence is made of experimental, modelling and simulation activities. Here, I focus on the advantages provided by modelling and interactive computer simulation activities in promoting student use of lines of reasoning useful to explain proposed or observed situations. I outline a mesoscopic model of liquid and examples of computer simulations. Simulations should provide a tool to understand the role played by relevant quantities involved in the surface phenomena. A preliminary study on the efficacy of the Teaching/Learning Sequence show that allowing students to control relevant physical quantities can improve students' reasoning.

▲ **L'arte della scienza - nuove prospettive per la diffusione della cultura scientifica.**

Baldanzi E. ([1])([2]), Farini A. ([1])([2]), Toninelli C. ([1])([2])([3]), Gurioli M. ([1])([3])
([1]) *CNR Istituto Nazionale di Ottica, Firenze, Italia*
([2]) *Dipartimento di Fisica e Astronomia, Università di Firenze, Firenze, Italia*
([3]) *LENS Laboratorio Europeo di Spettroscopia non Lineare, Firenze, Italia*

In una società in continua mutazione occorre ripensare a che cosa voglia dire comunicare la scienza. Questa curiosità ha dato vita a una rete di progetti per la diffusione della cultura scientifica che si snodano all'interno e all'esterno degli ambienti di ricerca. L'ispirazione è nata in modo modulare a partire da singole iniziative, come ad esempio la mostra "Enlighting Mind" esposta presso il Dipartimento di Fisica e Astronomia a Firenze, e dal confronto tra più Enti e istituzioni. Un forte impulso per dare una risposta contemporanea alla richiesta di comunicare la ricerca è stato inoltre generato dall'incontro tra gli Enti coinvolti e la Fondazione Palazzo Strozzi. La mostra "Olafur Eliasson: Nel tuo tempo", esposta a Firenze dal 22 settembre 2022 al 22 gennaio 2023, dedicata a uno degli artisti contemporanei più originali e visionari della nostra epoca, ha rappresentato una preziosa occasione di confronto e un laboratorio sperimentale attraverso un percorso ibrido in grado di generare esperienze e suscitare dibattito su temi a cui le opere d'arte e le teorie scientifiche tentano di dare un'interpretazione.

Comunicazioni

● **Quali concezioni hanno della Fisica gli studenti delle scuole secondarie?**

Bologna V., Peressi M.
Dipartimento di Fisica, Università di Trieste, Trieste, Italia

Utilizzando un metodo di ricerca misto multimodale abbiamo indagato le concezioni degli studenti delle scuole secondarie di secondo grado. Scopo della ricerca è stato quello di individuare le caratteristiche di tali concezioni secondo tre profili: quello degli atteggiamenti nei confronti della disciplina, quello relativo alla costruzione della conoscenza e infine quello che riguarda lo sviluppo di competenze soprattutto di ragionamento e di argomentazione. Per ciascun profilo sono stati utilizzati strumenti di indagine propri della ricerca in didattica della Fisica, quali un questionario sugli atteggiamenti verso la Fisica opportunamente costruito e validato, il test FMCE (Force and Motion Concept Evaluation), e infine l'analisi dei processi di ragionamento degli studenti in tre modi/momenti diversi dell'attività in classe (nel problem-solving, in esercizi on-line, nell'analisi di lezioni audio-registrate). Sotto aspetti diversi, l'indagine compiuta ha fatto emergere diverse criticità dal punto di vista dell'apprendimento, della conoscenza e dell'istruzione, suggerendo una revisione delle prassi didattiche.

● **Formare gli insegnanti di scuola primaria con e alla didattica laboratoriale: un esempio di buona pratica.**

D'Acunto I., Fattorusso Y., De Luca R.
Università di Salerno, Salerno, Italia

Le attività laboratoriali hanno un ruolo fondante nel processo di apprendimento degli studenti, ma ancor più nella formazione professionale degli insegnanti. Il lavoro di tesi di una futura insegnante di Scuola Primaria sviluppa proposte didattiche laboratoriali del nostro corso di Didattica della Fisica e di Laboratorio. Insufficienti attività laboratoriali snaturano la fisica in disciplina solo teorica, rendendola distante; l'apprendimento esperienziale, oltre che costruttivo, sviluppa in adulti e bambini emozioni positive nei confronti delle scienze. Formare un docente motivato e autonomo nell'implementare una didattica integrata con

esperimenti lo abilita ad avvicinare i bambini alla fisica e a divenire un seme per l'ambiente in cui educa. Tale formazione è stata arricchita dall'esperienza dei Musei Scientifici: il lavoro della tesista è partito dalla mostra "Divertiesperimenti" del Dipartimento di Fisica di Salerno, mini Science Center sul modello interattivo "hands-on" (piuttosto che "hands off" dei musei tradizionali). È proseguito poi presso Città della Scienza di Napoli, il Museo dei bambini Explora di Roma e anche studiando la mostra GEI dell'Università di Udine.

La prospettiva della fisica nell'approccio a problemi complessi: un'opportunità didattica.

Landi R.
I. I. S. "Gian Camillo Glorioso", Montecorvino Rovella, SA, Italia

Cosa accadrebbe se? Una domanda che rappresenta l'essenza della prospettiva fisica nell'approccio a problemi complessi e che può introdurre a una lettura del metodo scientifico funzionale a innovare la didattica della fisica: un cambiamento di paradigma basato sull'elaborazione di protocolli non manualistici che contestualizzino temi fisici caratteristici mediante compiti sfidanti. Osservare, formulare stime e ipotesi, riconoscere relazioni, modellizzare, verificare e confrontarsi tra pari. Sono queste le competenze da sviluppare e mobilitare, anche in riferimento a problemi reali e autentici, magari afferenti all'ambito del quotidiano, per cogliere una straordinaria opportunità didattica. Minds on, hands on, collaborative learning e coaching si integrano nel proporre situazioni da problematizzare, del tipo "stimolo aperto con risposta aperta". Lo stimolo parte da una domanda e non sono generalmente forniti dati che vanno invece ricercati o stimati in modo autonomo. Le strategie risolutive devono essere convenientemente argomentate e la soluzione stessa può non essere unica. È questa un'opportunità di "fare" fisica in modo diverso e di far emergere vocazioni naturali latenti.

L'entanglement: un nuovo basic concept della meccanica quantistica?

Truda L.
Università di Salerno, Salerno, Italia

Il Nobel del 2022 ha riconosciuto la potenza della meccanica quantistica, sottolineando come esperimenti pionieristici del secolo scorso possano trovare riscontri in test sperimentali in tempi moderni. La meccanica quantistica non finisce di meravigliare, ne è una prova l'entanglement, concetto cardine di questa teoria, che in questo periodo funge da rappresentante di un filone di grandi innovazioni che rivoluzioneranno le odierne tecnologie, basti pensare al quantum computing. Scopo della presentazione è illustrare le attività di frontiera della meccanica quantistica, legate alle implementazioni e investigazioni dell'entanglement, visto come risorsa tecnologica. A tal fine, si descriverà cos'è l'entanglement utilizzando un semplice esempio che non richiede l'utilizzo di alcuna matematica superiore né la conoscenza di argomenti di fisica moderna particolarmente avanzati. Si illustreranno, successivamente, i recenti risultati sui concetti base della meccanica quantistica nonché le applicazioni tecnologiche dell'entanglement che hanno favorito lo sviluppo di quella che viene ormai definita come la "seconda rivoluzione quantistica".

Quantum computing per studenti delle scuole superiori.

Villani L., Bruno V., Mazzotti A., Truda L.
Università di Salerno, Salerno, Italia

Il quantum computing è un ambito della ricerca, sia teorica che applicativa, che si colloca all'intersezione tra fisica e informatica e le cui basi sono riconducibili alla meccanica quantistica. In questa ottica difficilmente argomenti di tal genere sono trattati, anche superficialmente, nelle scuole superiori. L'obiettivo di questa presentazione sarà quello di introdurre,

tramite semplici argomenti di meccanica quantistica, le peculiarità del quantum computing agli studenti degli ultimi anni delle scuole superiori. Si porrà, in particolare, l'accento su risultati e possibilità controintuitive legate alle potenzialità del quantum computing. Si discuteranno, infatti, i meccanismi alla base della programmazione quantistica illustrando semplici algoritmi ben noti nella letteratura scientifica. Infine, dettagli saranno presentati per chiarire il ruolo del quantum computing per la crittografia, l'entanglement e il teletrasporto.

A schematic model for understanding harmonic oscillators in metals.

Lamberti V., Grimaldi A., Truda L.
Dipartimento di Fisica "E. R. Caianiello", Università di Salerno, Salerno, Italia

A model is proposed to help high-school or undergraduate students understand the concept of harmonic oscillators in metals. The goal is to establish a link between the idea of metallic bonding and both Newtonian mechanics and electricity concepts, employing classical physics arguments. To begin, students are introduced to a simplified representation of the problem, which involves two point-like charges (representing two ions) surrounded by a neutralizing electronic cloud. Through analyzing this system, students can conclude that the positive charges can be regarded as two massive bodies connected by a spring, with an elastic constant that depends on various electrical parameters. The electronic cloud generates an attractive interaction that provides stability to the system, without contributing to the inertial properties of the two massive bodies. This approach offers a clear and accessible way for students to understand some fundamental characteristics of metals, such as the Dulong-Petit law, through the properties of harmonic oscillators. By providing a basic model and gradually building upon it, students can develop a deeper understanding of this crucial concept in physics.

From Feynman's double slit to the Nobel 2022 experiments: a "quantum stage"' for secondary school students.

De Renzi V., Goldoni G., Corradini O.
Dipartimento di Scienze Fisiche, Informatiche e Matematiche, Università di Modena e Reggio Emilia e Istituto CNR-NANO, Modena, Italia

Since the emergence of Quantum Technologies, the need for educational/outreach initiatives which introduce the basis of Quantum Mechanics at the secondary school level "thus fostering a generation of *quantum-thinkers*" has become increasingly urgent. In this context, we devised a route to introduce the key concepts of quantum superposition and entanglement at the secondary school level, which has been proposed to fourth- and fifth-grade students during a three-days stage, within the framework of the Italian Quantum Weeks initiatives and within the objectives of the national project "Piano Nazionale Lauree Scientifiche". Main cornerstones of the proposed sequence are a few key experiments, which are illustrated using videos and interactive models: i) Feynman's double slit experiment to introduce quantum superposition; ii) Stern Gerlach experiment to introduce both the electron spin and the idea of non-commutative measurements; iii) the Nobel 2022 experiments, which demonstrate the violation of Bell's inequalities. Gamification of both Bell's inequalities (in their CHSH form) and Nobel experiments, are further key ingredients of our sequence.

Aula F1 - Augusta Manfredini **ore 09:00 – 13:30**

Sezione I

Fisica nucleare e subnucleare

Presiede: Pirrone S. (INFN, Sezione di Catania)

Relazioni su invito

▲ **How does subatomic matter organize itself?**

Roca-Maza X.

Università degli Studi di Milano e INFN, Sezione di Milano

I will briefly introduce the strong synergy between "Heaven and Earth" which is instrumental in the study of the nuclear Equation of State (EoS). That is, the relevance of ground experiments as well as accurate astronomical observations on neutron stars and gravitational waves to shed light on one of the most challenging problems of our times: how does subatomic matter organize itself?

▲ **Status and perspectives of LNL physics programs.**

Goasduff A.

INFN, Laboratori Nazionali di Legnaro

The Legnaro National Laboratories (LNL) are a user-oriented large-scale facility mainly dedicated to research programs in nuclear physics and nuclear astrophysics, and to high-level technology developments relevant to several disciplines. The LNL accelerator complex consists in two smaller electrostatic accelerators (the 2 MV AN2000 and the 7 MV CN) and the Tandem-ALPI- PIAVE complex. In addition, the SPES (Selective Production of Exotic Species) project will provide second-generation ISOL beams. SPES is the most important initiative of LNL and thus is the central part of the mid- and long-term strategy of the laboratory. The SPES project is based on a dual-exit cyclotron B70 providing intense proton beams. The facility will provide both low-energy and re-accelerated radioactive ion beams to carry out forefront research in nuclear physics, nuclear astrophysics, and R&D of novel medical radionuclides. The available stable beam facilities at LNL together with the state-of- the-art instrumentation will be discussed as well as the status of the SPES radioactive ion beam facility. These two branches are making the LNL an attractive pole for worldwide users.

▲ **Status and perspectives of LNS nuclear physics programs.**

La Cognata M.

INFN, Laboratori Nazionali del Sud, Catania, Italy

The INFN-Laboratori Nazionali del Sud are a leading laboratory in the field of nuclear, astronuclear, astroparticle, and applied physics. In the area of nuclear structure and dynamics, recent studies have focused on the nuclear equation of state, with reference to the isospin degree of freedom, and on the study of double charge-exchange reactions for applications to the neutrinoless double-beta decay. In nuclear astrophysics, nucleosynthesis in evolved massive stars has been addressed, highlighting the link with the structure of light nuclei. In the coming years, new facilities will be in operation, allowing the nuclear physics program to be further extended. The cyclotron upgrade and the FRAISE in-flight radioactive ion beam facility will make it possible to deduce the nuclear matrix elements from the double charge-exchange reactions and to study nuclear reaction induced by short-lived radioactive beams.

The PANDORA plasma trap will make it possible to study beta decays in plasma closer to astrophysical conditions and to conduct research on applied physics. I will give highlights of the whole research activity with a focus on the current and future nuclear physics programs.

▲ **Ricerche di dinamica e struttura nucleare della Collaborazione NUCL-EX a GANIL.**

Lombardo I. per la NUCL-EX Collaboration
Dipartimento di Fisica e Astronomia, Università di Catania e INFN, Sezione di Catania

In questa comunicazione verranno descritte alcune attività sperimentali condotte dalla collaborazione NUCL-EX presso i laboratori GANIL. Esse hanno riguardato principalmente lo studio della dinamica nucleare e dell'influenza del grado di libertà dell'isospin sull'equazione di stato della materia nucleare. Tali studi sono stati condotti utilizzando il multi-rivelatore INDRA-FAZIA, che rappresenta lo stato dell'arte in termini di identificazione isotopica e risoluzione in energia in questo campo della fisica nucleare. Sono stati osservati effetti di diffusione dell'isospin tra i due partner di reazione durante la fase di interazione, che sono stati accuratamente investigati in funzione del parametro di impatto della collisione. Verrà inoltre realizzato un esperimento di struttura nucleare con il tracciatore ACTAR. Durante tale esperimento verranno determinate le sezioni d'urto e le distribuzioni angolari della reazione $^{4}\mathrm{He} + {}^{8}\mathrm{Li} \rightarrow \mathrm{n} + {}^{11}\mathrm{B}$, che permetteranno di investigare la struttura del ^{12}B in una regione di energia dove diversi modelli microscopici prevedono l'esistenza di alfa clustering. Verrà infine discusso l'impatto astrofisico della misura assoluta di tali sezioni d'urto.

▲ **Chirone in Europa (indagini ai confini dell'energia di Fermi).**

Geraci E.
Università Catania e INFN, Sezione di Catania

Oltre all'attività svolta con il multirivelatore CHIMERA e con il correlatore FARCOS presso i Laboratori Nazionali del Sud dell'INFN a Catania, il gruppo di afferenza all'esperimento CHIRONE svolge attività in collaborazione con altri laboratori europei, principalmente GSI (Darmstadt, Germania) e HIL (Varsavia, Polonia). In questa comunicazione vengono illustrati i più recenti risultati raggiunti, le attività in corso e quelle future che consentono di estendere il campo di indagine delle energie di Fermi, approfondendo in seno alla collaborazione Nustar/R3B aspetti legati all'equazione di stato della materia nucleare a densità superiori a quella di saturazione e al HIL processi di fusione intorno alla barriera coulombiana.

Comunicazioni

● **Collective modes of excitation in ^{64}Cu.**

Saracino A. ([1])([2]), Zhu S. ([3]), Sensharma N. ([1])([2]), Ayangeakaa A.D. ([1])([2]), Janssens R.V.F. ([1])([2]), Chen Q.B. ([4]), Carpenter M.P. ([5]), Chowdhury P. ([6]), Gade A. ([7])([8]), Kondev F.G. ([5]), Kowalewski T.M. ([1])([2]), Lauritsen T. ([5]), McCutchan E.A. ([3]), Seweryniak D. ([5])
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Medium- and high-spin level sequences in ^{64}Cu were investigated using the complex ^{26}Mg(^{48}Ca, $\alpha p5n\gamma$) multinucleon transfer reaction. The experiment was performed with ATLAS accelerator facility at the Argonne National Laboratory using the Gammasphere array and the fragment mass analyzer (FMA). Two high-spin, quasirotational bands consisting of stretched-$E2$ transitions were observed in coincidence with the known low-spin structure for the first time. These bands share remarkable similarities with highly deformed and/or superdeformed bands observed in the $A \approx 60$–70 mass region. In addition, a regular dipole sequence with weak $E2$ crossover transitions was observed as well. A general discussion of the observed structures, complemented by theoretical calculations within the framework of the adiabatic and configuration-fixed constrained covariant density functional theory and the quantum particle-rotor model are presented in the context of shell-structure evolution and the collectivity in the mass region.

Search for the shape coexistence phenomenon in selenium isotopes near the $N = 50$ shell closure.

Ciconali G. (1)(2), Conca F. (1), Sferrazza M. (3), Bottoni S. (1)(2), Leoni S. (1)(2), Fornal B. (4), Michelagnoli C. (5), Corbari G. (1)(2), Luciani M. (1)(2), Colombi G. (1)(2)(5), Porzio C. (1)(2), Crespi F. (1)(2), Cieplicka N. (4), Iskra L. (4), Jentschel M. (5), Koester U. (5), Borcea R. (6), Boromiza M. (6), Călinescu S. (6), Clisu-Stan C. (6), Costache C. (6), Filipescu D. (6), Florea N. (6), Gheorghe I. (6), Ionescu A. (6), Mărginean N. (6), Mărginean R. (6), Mihai C. (6), Mihai R.E. (6), Neacşu C. (6), Negreţ A. (6), Niţă C.R. (6), Olăcel-Coman A. (6), Pascu S. (6), Petrone C. (6), Stan L. (6), Sotty C. (6), Turturică A. (6), Turturică G. (6), Toma S. (6), Ujeniuc S. (6)

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(6) *Horia Hulubei National Institute for Physics and Nuclear Engineering, IFIN-HH, Măgurele, Romania*

We discuss the investigation of the shape coexistence phenomenon near the $N = 50$ shell closure in the neutron-rich selenium ($Z = 34$) chain, by gamma-ray spectroscopy. The ^{84}Se ($N = 50$) and ^{83}Se ($N = 49$) nuclei have been populated by a sub-Coulomb barrier transfer reaction at IFIN-HH and by a neutron capture reaction at ILL, respectively. In the case of ^{84}Se, two excited 0^+ states, already known from the literature, have been confirmed at 2244 keV and 2654 keV, and their gamma decay to the first 2^+ state was observed for the first time. Preliminary results from lifetime analyses indicate that the lifetime of the third 0^+ is of the order of 1 ps, while a longer lifetime is expected for the second 0^+ state. For the ^{83}Se nucleus, the current gamma-spectroscopy data allowed to significantly expand the decay scheme of the nucleus, through the observation of 28 new primary gammas, 89 new secondary transitions and 16 new populated energy levels. The data analysis is still ongoing and firm spin and parity assignments of newly found states will be obtained from angular correlation investigation.

Ricerca di configurazioni a cluster nello scattering elastico p + ^{12}C tramite metodi di diffrazione.

Redigolo L. (1)(2), Dell'Aquila D. (3)(4), Lombardo I. (1)(2), Musumarra A. (1)(2), Pellegriti M. (2), Verde G. (2), Vigilante M. (4)

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Questa comunicazione descrive uno studio di distribuzioni angolari ottenute da diversi esperimenti di scattering elastico di protoni su ^{12}C, per investigare la presenza di configurazioni a cluster α nello stato fondamentale del ^{12}C. Questi studi sono rivelanti per ricercare la presenza di simmetrie discrete dovute alla presenza di strutture geometriche peculiari. Il contributo da struttura sferoidale (associato a strutture non-cluster) è dunque stato descritto tramite calcoli di Canale Accoppiato, mentre i contributi dovuti a possibili configurazioni a cluster α con simmetria trigonale sono stati considerati tramite formule di scattering diffrattivo; ciò è giustificato dal fatto che, alle energie del fascio prese in considerazione, la lunghezza d'onda di de Broglie dei protoni incidenti risulta confrontabile con la distanza stimata tra i cluster α. Si è quindi ottenuta una frazione piuttosto bassa di componente a cluster α, con valore massimo di frequenza di manifestazione dell'1% ed elevato intervallo di confidenza; il valore di distanza tra cluster α all'interno del nucleo è di ~ 3.9 fm, risultati confrontati con diverse predizioni teoriche attualmente esistenti in letteratura.

● **Risultati preliminari ottenuti con il multi-rivelatore CHIMERA nell'esperimento CHIFAR.**

Russotto P. ([1]), De Filippo E. ([2]), Pagano E.V. ([1]), Acosta L. ([3]), Cap T. ([4]), Cardella G. ([2]), Castoldi A. ([5])([6]), Geraci E. ([2])([7]), Gnoffo B. ([2])([7]), Guazzoni C. ([5])([6]), Lanzalone G. ([1])([8]), Maiolino C. ([1]), Martorana N.S. ([1])([7]), Matulewicz T. ([9]), Pagano A. ([2]), Papa M. ([2]), Piasecki K. ([9]), Pirrone S. ([2]), Planeta R. ([10]), Politi G. ([2])([7]), Risitano F. ([2])([11]), Rizzo F. ([1])([7]), Santagati G. ([2]), Siwek-Wilczynska K. ([9]), Skwira-Chalot I. ([9]), Trimarchi M. ([2])([11]), Zagami C. ([1])([7])
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L'esperimento CHIFAR è stato effettuato presso i Laboratori Nazionali del Sud (INFN) utilizzando il multi-rivelatore CHIMERA accoppiato a 10 telescopi del correlatore FARCOS. Reazioni tra fasci di ^{124}Sn, ^{112}Sn, ^{124}Xe a 20 MeV/nucleone e bersagli di ^{64}Ni, ^{58}Ni, ^{64}Zn sono state investigate allo scopo di studiare il meccanismo di reazione, con particolare attenzione al processo di emissione dei frammenti di massa intermedia (IMF) in collisioni semi-periferiche, estendendo a più bassa energia gli studi precedentemente effettuati alla energia incidente di 35 MeV/nucleone. La misura di diverse combinazioni proiettile/bersaglio, con diverso contenuto di Isospin, consente anche lo studio della eventuale dipendenza dei meccanismi di reazione dal contenuto di Isospin del canale di ingresso. I risultati preliminari sulla porzione di dati relativi al multi-rivelatore CHIMERA saranno presentati e discussi.

Recenti risultati del correlatore FARCOS nell'esperimento CHIFAR.

Zagami C. ([1])([2])([3]), Pagano E.V. ([1]), Russotto P. ([1]), De Filippo E. ([4]), Acosta L. ([5]), Cap T. ([6]), Cardella G. ([4]), Fichera F. ([4]), Geraci E. ([2])([4]), Gnoffo B. ([2])([4]), Guazzoni C. ([7])([8]), Lanzalone G. ([1])([9]), Maiolino C. ([1]), Martorana N.S. ([1])([2]), Matulewicz T. ([10]), Pagano A. ([4]), Papa M. ([4]), Piasecki K. ([10]), Pirrone S. ([4]), Piscopo M. ([1]), Planeta R. ([11]), Politi G. ([2])([4]), Risitano F. ([4])([12]), Rizzo F. ([1])([2])([3]), Saccà G. ([4]), Santagati G. ([4]), Siwek-Wilczynska K. ([10]), Skwira-Chalot I. ([10]), Trimarchi M. ([4])([12])

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Nell'esperimento CHIFAR, presso i LNS-INFN, si è proposto lo studio della probabilità di emissione dei Frammenti di Massa Intermedia (IMFs) in collisioni non centrali, investigando il ruolo dell'isospin dei nuclei collidenti. Sono state analizzate tre reazioni nucleari, ad energia di fascio di 20 AMeV: ^{124}Sn + ^{64}Ni, ^{112}Sn + ^{58}Ni e ^{124}Xe + ^{64}Zn. Il setup sperimentale ha usato 10 telescopi del correlatore FARCOS (Femtoscope ARray for COrrelation and Spectroscopy), accoppiati al multi-rivelatore CHIMERA: l'elevata risoluzione angolare ed energetica del primo, unita alla copertura angolare a 4π e granularità del secondo, hanno reso possibile lo studio di correlazioni tra IMFs. Ogni telescopio di FARCOS è costituito da 2 Double Sided Silicon Strip Detectors (DSSSD), di spessore 300 μm e 1500 μm, rispettivamente, e da 4 cristalli di CsI(Tl), di spessore 6 cm. FARCOS è stato posizionato tra 13°–30° nel sistema del laboratorio e si è ottenuta buona identificazione degli IMFs in carica fino a $Z \approx 16$ e isotopica in massa fino a $Z \approx 9$, mediante la tecnica $\Delta E - E$ applicata ai primi due stadi del rivelatore.

Shape coexistence in Sn isotopes around $A = 110$.

Corbari G. ([1])([2]), Leoni S. ([1])([2]), Benzoni G. ([2]), Bottoni S. ([1])([2]), Camera F. ([1])([2]), Ciconali G. ([1])([2]), Crespi F.C.L. ([1])([2]), Million B. ([2]), Wieland O. ([2]), Fornal B. ([3]), Ciemała M. ([3]), Cieplicka-Orynczak N. ([3]), Iskra Ł. ([3]), Matejska-Minda M. ([3]), Mărginean N. ([4]), Mihai C. ([4]), Costache C. ([4]), Mărginean R. ([4]), Turturică A. ([4]), Ujeniuc S. ([4]), Cuciuc C.M. ([5]), Balogh M. ([6]), Brugnara D. ([6]), Ertoprak A. ([6]), Galtarossa F. ([6]), Goasduff A. ([6]), Gottardo A. ([6]), Napoli D.R. ([6]), Pellumaj J. ([6]), Pérez-Vidal R.M. ([6]), Sedlak M. ([6]), Valiente-Dobon J.J. ([6]), Zanon I. ([6]), Aguilera P. ([7]), Benito J. ([7]), Carollo S. ([7]), Escudeiro R. ([7]), Lenzi S.M. ([7]), Mengoni D. ([7]), Pigliapoco S. ([7]), Pilotto E. ([7]), Polettini M. ([7]), Recchia F. ([7]), Rezynkina K. ([7]), Zago L. ([7]), Zhang G. ([7]), Zhen H. ([7]), Colombi G. ([1])([8]), Michelagnoli C. ([8]), Sferrazza M. ([9]), Otsuka T. ([10]), Tsunoda Y. ([10])

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The shape coexistence phenomenon, a major topic in modern nuclear physics, was investigated in Sn isotopes around $A = 110$ via γ-ray spectroscopy and lifetime measurements of low-spin states. Two experiments were performed at LNL with the AGATA-PRISMA setup and at IFIN-HH with the ROSPHERE-SORCERER array. In both cases, the Recoil Distance Doppler Shift method was applied to determine the lifetime of excited states in ^{110,112}Sn and ^{114}Sn nuclei, which were populated by low-energy multi-nucleon transfer reactions. Of particular interest is the lifetime of excited 0^+ states, which can be interpreted as ground states of configurations built on different nuclear deformation. The analysis is ongoing and results will be compared with state-of-the-art Monte Carlo Shell Model calculations, giving an insight into the microscopic mechanism leading to the onset of deformation in atomic nuclei.

● **Search for the γ decay of the narrow near-threshold proton resonance in ^{11}B.**
Bottoni S. ([1])([2]), Albanese E. ([1])([2]), Leoni S. ([1])([2]), Fornal B. ([3]), Capra S. ([1])([2]), Goasduff A. ([4]), Ziliani S. ([1])([2]), Benzoni G. ([2]), Brugnara D. ([4])([5]), Camera F. ([1])([2]), Ciemala M. ([3]), Cieplicka-Orynczak N. ([3]), Corbari G. ([1])([2]), Cortes L. ([4]), Duenas J. ([6]), Gadea A. ([7]), Galtarossa F. ([4]), Gamba E. ([1])([2]), Gottardo A. ([4]), Gregor E. ([4]), Iskra L. ([3]), Mengoni D. ([5])([8]), Million B. ([2]), Pasqualato G. ([5])([8]), Pellumaj J. ([4])([9]), Polettini M. ([1])([2]), Pullia A. ([1])([2]), Recchia F. ([5])([8]), Valiente-Dobon J.J. ([4]), Wieland O. ([2]), Zanon I. ([4])([9]), Zhang G. ([5])([8])
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We present recent results on the γ decay of a peculiar near-threshold state in ^{11}B, expected to be located in the continuum just above the proton-decay threshold at 11.2 MeV. The relevance of such a state is due to the observation of the rare β-delayed proton emission process in the neutron-rich ^{11}Be nucleus, with an unexpectedly high rate. This phenomenon might be explained by the presence of a near-threshold proton resonance in ^{11}B, recently suggested in two different experiments using particle spectroscopy techniques. A step forward can be made by searching for the γ decay of this near-threshold proton state in ^{11}B, since the γ-decay branch is extremely sensitive to the structure of the resonance wave function. The experiment was performed at Laboratori Nazionali di Legnaro using the ^{6}Li(^{6}Li, p)^{11}B fusion-evaporation reaction and the GALILEO-TRACE setup for the coincident detection of γ-rays and charged particles. For the first time, a limit on the γ-decay branch was established and implications for the description of ^{11}B as an open quantum system will be discussed.

Testing the Pauli Exclusion Principle with the VIP-2 experiment and beyond.
De Paolis L.
INFN, National Laboratories of Frascati, LNF
The Pauli Exclusion Principle (PEP) is a fundamental pillar of Quantum Field Theory, explaining various phenomena ranging from the stability of matter to the existence of neutron stars to superconductivity. PEP violation may be connected to theories beyond the Standard Model. The VIP-2 experiment, presently installed at the Underground Gran Sasso Laboratory (LNGS), aims to perform high-precision tests of the PEP for electrons in copper atoms. The experimental method consists in circulating a DC current in a copper strip, searching PEP forbidden $2p \rightarrow 1s$ transition (occurring when two electrons already occupy the $1S$ level) with cutting-edge X-ray spectroscopy. The LNGS underground laboratories provide a clean background environment, ideal for precision measurements of rare X-ray processes. In 2011, the VIP experiment set the best upper limit on the PEP violation probability for electrons $\frac{1}{2}\beta^2 < 4.7 \times 10^{-29}$. The VIP-2 experiment aims to improve this result by two orders of magnitude at least. The VIP-2 theory, purposes and apparatus will be presented. A new improved upper limit on the PEP violation probability will be presented.

Recenti sviluppi sull'elettronica di readout del prototipo del correlatore NArCoS.
Pagano E.V. ([1]), Boiano C. ([2]), Cardella G. ([3]), Castoldi A. ([2])([5]), De Filippo E. ([3]), Geraci E. ([3])([4]), Gnoffo B. ([3])([4]), Guazzoni C. ([2])([5]), Lanzalone G. ([1])([6]), Maiolino C. ([1]), Martorana N.S. ([3]), Pagano A. ([3]), Pirrone S. ([3]), Politi G. ([3])([4]), Risitano F. ([3])([7]), Rizzo F. ([1])([4]), Russotto P. ([1]), Santagati G. ([3]), Trimarchi M. ([3])([7]), Zagami1 C. ([4])
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Rivelare neutroni e particelle cariche leggere con alta risoluzione angolare ed energetica acquisisce una importanza strategica per i futuri studi di dinamica e struttura nucleare che saranno condotti con i fasci radioattivi che verranno prodotti nelle nuove facilities come FRAISE ai LNS, SPES ai LNL e FAIR al GSI, per fare qualche esempio europeo. La costruzione di un prototipo di correlatore, NArCoS (Neutron Array for Correlation Studies) ha tratto nuova linfa dal progetto PRIN ANCHISE (2020H8YFRE), che tra i suoi scopi si propone di utilizzare un materiale scintillatore di nuova generazione accoppiato a fotosensori compatti SiPM come elemento base del correlatore. Nella presente comunicazione verranno presentati gli ultimi sviluppi e test del rivelatore, in particolare un prototipo di elettronica di readout in grado di sommare i segnali provenienti dalla matrice di SiPM e rendendo così il segnale somma ottenuto disponibile per l'acquisizione digitale.

Studio di efficienza e della probabilità di cross-talk per il correlatore di neutroni NArCoS.
Santagati G. ([1]), Pagano E.V. ([2]), Boiano C. ([3]), Cardella G. ([1]), Castoldi A. ([3])([4]), De Filippo E. ([1]), Geraci E. ([1])([5]), Gnoffo B. ([1])([5]), Guazzoni C. ([3])([4]), Lanzalone G. ([2])([6]), Maiolino C. ([2]), Martorana N.S. ([1]), Pagano A. ([1]), Pirrone S. ([1]), Politi G. ([1])([5]), Risitano F. ([1])([7]), Rizzo F. ([2])([5]), Russotto P. ([2]), Trimarchi M. ([1])([7]), Zagami C. ([2])([5])

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La rivelazione di neutroni e particelle cariche leggere con alta risoluzione angolare ed energetica rappresenta una caratteristica di fondamentale importanza per i futuri esperimenti con fasci radioattivi che verranno prodotti dalle nuove facilities come FRAISE ai LNS, SPES ai LNL e FAIR al GSI. In questo contesto si inserisce il progetto PRIN ANCHISE (2020H8YFRE), il cui scopo è investigare la possibilità di utilizzare un materiale scintillatore plastico di nuova generazione, denominato EJ276, accoppiato a fotosensori compatti SiPM come elemento base di un multi rivelatore segmentato e versatile capace di rivelare allo stesso tempo neutroni e particelle cariche leggere entrambi con alta risoluzione angolare ed energetica. Nella presente comunicazione verranno mostrati gli ultimi risultati ottenuti mediante simulazioni Monte Carlo (GEANT4) realizzate per diverse configurazioni geometriche dell'EJ276, in dimensioni ($3 \times 3 \times 3$ cm^3), allo scopo di valutare le efficienze di rivelazione in funzione dell'energia dei neutroni incidenti e la probabilità di cross-talk tra le celle di rivelazione.

● **Stato dello sviluppo di un nuovo sistema di diagnostica e tagging per fasci radioattivi basato sulla tecnologia SiC.**

Martorana N.S. ([1]), Acosta L. ([2]), Altana C. ([3]), Amato A. ([3]), Cardella G. ([4]), Caruso A. ([3]), Cosentino L. ([3]), Costa M. ([3]), De Filippo E. ([4]), De Luca G. ([3]), De Luca S. ([3]), Geraci E. ([1])([4]), Gnoffo B. ([1]), Guazzoni C. ([5]), Maiolino C. ([3]), Pagano E.V. ([3]), Passarello S. ([3]), Pirrone S. ([4]), Politi G. ([1])([4]), Pulvirenti S. ([3]), Risitano F. ([4])([6]), Rizzo F. ([1])([3]), Russo A.D. ([3]), Russotto P. ([3]), Santonocito D. ([3]), Trifirò A. ([6]), Trimarchi M. ([4])([6]), Tudisco S. ([3]), Vecchio G. ([3])
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La produzione di fasci radioattivi (RIBs) di alta intensità apre interessanti prospettive sia per la fisica fondamentale sia per le applicazioni. Molte facility sono in costruzione o in upgrade per produrre RIBs di alta intensità. Tra queste l'apparato FRAISE (FRAgment In-Flight Separator), attualmente nelle fasi finali di costruzione presso i Laboratori Nazionali del Sud dell'INFN, sarà capace di fornire RIBs di intensità 103–107 pps nel regime dell'energia di Fermi, utilizzando il metodo in-flight. Al fine di effettuare studi con RIBs di alta intensità sono necessari sistemi di tagging e diagnostica resistenti alle radiazioni e che consentano di misurare tempo di volo, perdita di energia, distribuzione angolare, profilo dei fasci e identificazione isotopica, ad esempio tramite la tecnica ΔE-TOF. In questo contributo si presenta lo stato di avanzamento dello sviluppo di un sistema di tagging e diagnostica basato su una matrice di diodi in SiC letti da una elettronica veloce dedicata. Il sistema è stato principalmente sviluppato per l'apparato FRAISE@LNS-INFN ma grazie alle sue potenziali prestazioni e alla sua versatilità potrà essere utilizzato anche in altre facility.

Aula F8 - Maria Marinaro **ore 09:00 – 13:30**

Sezione II
Fisica della materia
Presiede: Fazio R. (Università di Napoli e SISSA, Trieste)

Relazioni su invito

▲ **Tuning ferromagnetism in an oxide quasi-two-dimensional electron gas.**
Stornaiuolo D. ([1])([2]), D'Antuono M. ([1])([2]), Chen Y. ([2]), Caruso R. ([1])([2])([3]), Jouault B. ([4]), Verma M. ([5]), Pentcheva R. ([5]), Salluzzo M. ([2])
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Transition metal oxide heterostructures have attracted vast interest since the breakthrough discovery of the quasi-two-dimensional electron gas (q2DEG) at the interface between the two complex-oxide band insulators $LaAlO_3$ (LAO) and $SrTiO_3$ (STO). Recently, it was demonstrated that this q2DEG can be made spin-polarized by introducing a thin layer of a magnetic oxide between LAO and STO, as in LAO/$EuTiO_3$/STO (LAO/ETO/STO). We will we review the main properties of the latter system focusing on the mechanism of orbital selective switching of the spin-polarization in the oxide q2DEG and show how the transport properties can be tuned using a wide range of stimuli, from field effect to visible light irradiation. Finally, we will discuss possible applications of these heterostructures for novel and spintronic oxide devices.

▲ **Oxide interfaces: A versatile platform for material design and ultrafast light control.**
Caviglia A.
Department of Quantum Matter Physics, University of Geneva, Geneva, Switzerland
Exerting control over quantum materials is one of the main goals in condensed matter physics. Oxide interfaces have emerged as a versatile platform for material design, where new fundamental properties can be controlled by assembling condensed matter at the atomic scale. Light plays a pivotal role in this scientific exploration. Probing materials with light reveals the collective excitations and the energy landscapes that underpin correlated dynamics. Recently we have come to the realisation that light not only reveals the organisation of condensed matter, it can also unlock new properties and promote phase transitions. The overarching goal of the field is to control macroscopic material properties, paving the way to new scientific insights and future emerging technologies. We will discuss two examples of material design at oxide interfaces, focusing on the control of geometric phases and magnetic order.

▲ **Unconventional superconducting quantum devices.**
Brosco V.
ISC-CNR, Institute for Complex Systems, Consiglio Nazionale delle Ricerche, Rome, Italy e Physics Department, Università di Roma, La Sapienza, Rome, Italy
Recent advances in creating van der Waals heterostructures hosting ultrathin electronic states and in the fabrication of hybrid Josephson nanostructures opened new research pathways aimed at understanding and controlling the rich array of exotic electronic properties

and functionalities emerging in these hybrid superconducting systems. In this talk, after bird's eye introduction on superconducting quantum devices, we focus on the potentialities offered by the integration of superconducting nanostructures and hybrid Josephson junctions in standard quantum superconducting nanocircuits. We discuss in particular the possibility to exploit conventional superconducting qubits as probes of noise fluctuations generated by these heterostructures.

Comunicazioni

Reconstruction-induced φ_0 Josephson effect in quantum spin Hall constrictions.

Vigliotti L. ([1]), Cavaliere F. ([1])([2]), Passetti G. ([3])([4]), Sassetti M. ([1])([2]), Traverso Ziani N. ([1])([2])

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The simultaneous breaking of time-reversal and inversion symmetry, in connection to superconductivity, leads to transport properties with disrupting scientific and technological potential. Indeed, the anomalous Josephson effect and the superconducting diode effect hold promises to enlarge the technological applications of superconductors and nanostructures in general. In this context, the system we theoretically analyze is a Josephson junction (JJ) with coupled reconstructed topological channels as a link; such channels are at the edges of a two-dimensional topological insulator (2DTI). We find a robust φ_0 Josephson effect without requiring the presence of external magnetic fields. Our results, which rely on a fully analytical analysis, are substantiated by means of symmetry arguments: our system breaks both time-reversal symmetry and inversion symmetry. Moreover, the anomalous current increases as a function of temperature. We interpret this surprising temperature dependence by means of simple qualitative arguments based on Fermi's golden rule.

Hallmarks of orbital-flavored Majorana states in Josephson junctions based on oxide nanochannels.

Maiellaro A. ([1]), Settino J. ([2]), Guarcello C. ([1]), Romeo F. ([1]), Citro C. ([1])

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Topological superconductivity (TSC) is an exotic phase of matter in which the fully gapped superconducting bulk hosts Majorana bound states protected by non-Abelian statistics and/or symmetries. In condensed matter systems, the realization of TSC has been mainly focused on platforms realized by semiconducting nanowires proximized by a conventional superconductor. On the other hand, very recently, evidence of topological superconductivity has also been discussed at LAO/STO interfaces. In this talk, we present the transport properties of an oxide-based Josephson junction, made by constraining the 2DEG at LAO/STO (001) interface, to form a quasi-1D system. Our main result is that the strong enhancement of the critical current with applied magnetic field can be associated with the appearance of Majorana bound states with an orbital-flavoured internal structure, lacking a counterpart in a single-band model. Our findings demonstrate that some recent experimental evidence of anomalous Josephson pattern is a strong hallmark of topology.

Charge-to-spin interconversion at (111) oxide interfaces.

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Converting charge current into spin current is one of the main mechanisms exploited in spintronics. One prominent example is the Edelstein effect, namely, the generation of a magnetization in response to an external electric field, which can be realized in systems with lack of inversion symmetry. If a system has electrons with an orbital angular momentum character, an orbital magnetization can be generated by the applied electric field, giving rise to the so-called orbital Edelstein effect. Oxide heterostructures are the ideal platform for these effects due to the strong spin-orbit coupling and the lack of inversion symmetries. Beyond a gate-tunable spin Edelstein effect, we predict an orbital Edelstein effect an order of magnitude larger than the spin one at the (111) $LaAlO_3/SrTiO_3$ interface. We model the material as a bilayer of t_{2g} orbitals using a tight-binding approach, and show that the hybridization between the electronic bands crucially impacts the Edelstein susceptibility.

Superconducting order parameter in NbRe/Co hybrids.

Cirillo C. ([1]), Strohmeier M. ([2]), Rovirola M. ([3])([4]), González C. ([3])([4]), Casals B. ([3])([4]), Macià F. ([3])([4]), Hernàndez J.M. ([3])([4]), Makhdoumi Kakhaki Z. ([5]), Scheer E. ([2]), García-Santiago A. ([3])([4]), Di Bernardo A. ([2])([5]), Attanasio C. ([5])

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Non-centrosymmetric superconductors (NCSs) are a fascinating class of materials. The lack of the inversion symmetry in their crystal structure may produce an unconventional superconducting gap, with a mixture of spin-singlet and spin-triplet components. This can open the path to the generation and control of spin-polarized supercurrents, with perspectives in basic research and applications. Here we present the results of the investigation of the superconducting order parameter of NCS NbRe films and NbRe-based ferromagnetic (NCS/F) hybrids by using different experimental techniques. The dependence of the superconducting critical temperature (T_c) of NbRe/Co bilayers on the thickness of the Co layer exhibits a very slow decay compared to the behavior of conventional Nb/Co bilayrs. Ferromagnetic resonance measurements on NbRe/Co/NbRe trilayers also give unusual results compared to other S/F/S systems, such as an almost unperturbed damping coefficient below T_c. Finally, low-temperature scanning tunnelling microscopy on NbRe and NbRe/Co bilayers reveal a complex dependence of the density of states on the magnetic field. Results and future experiments are discussed.

The role of the pinning crossover in the increase of the superconducting critical current density.

Galluzzi A. ([1])([2]), Buchkov K. ([3]), Modestino M. ([1]), Dinelli F. ([4]), Tomov V. ([3]), Nazarova E. ([3]), Leo A. ([1])([2]), Grimaldi G. ([2]), Polichetti M. ([1])([2])
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In the framework of the applications of superconductivity, the critical current density J_c plays an important role since it is the maximum current that a superconductor can carry without dissipation. In this context, the Second Magnetization Peak (SMP) phenomenon produces an increase in J_c as a function of the field (H). Another important parameter is the creep rate S which gives information about the vortex activity. Here, the correlation in type-II superconductors between S and the SMP phenomenon has been investigated at different temperatures by starting from the minimum in $S(H)$ and the onset of the SMP phenomenon detected on a $FeSe_{0.5}Te_{0.5}$ sample. We have found that the flux dynamic mechanisms behind the appearance of the SMP phenomenon in $J_c(H)$ are activated at fields well below those where the critical current starts effectively to increase. Moreover, both the $S(H)$ and the SMP phenomenon can be attributed to a sequential crossover between a less effective pinning (losing its effectiveness at low fields) to a more effective pinning (still acting at high fields), regardless of the type-II superconductor taken into consideration.

On the Bardeen-Cooper-Schrieffer interaction in quantum graphs.

Romeo F.
Dipartimento di Fisica "E.R. Caianiello", University of Salerno, Italy

We introduce a real-space version of the Bardeen-Cooper-Schrieffer interaction allowing the investigation of the non-trivial interplay between many-body physics and particles confinement on a quantum graph. When the two-body problem is considered, we find that the two-particle wave function is solution of an integro-differential Schrödinger equation. The solution of the two-body eigenproblem shows the presence of a two-particle bound state whose stability is enhanced in quantum graphs with peculiar network topology. We demonstrate that the enhancement effect is robust against many-body effects, which can be studied by means of the Richardson exact solution of the many-body problem. These findings suggest that the effective pairing interaction can be enhanced in quantum graphs with peculiar connectivity. Experimental evidences in Josephson junctions arrays are also discussed in connection with the microscopic mechanism described in the present work.

Bipolar thermoelectrical superconducting quantum interference proximity transistor (BTSQUIPT).

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We explore the electrical transport properties of a Josephson device under a temperature gradient. We discuss the bipolar quasiparticle thermoelectric effect, generated by the spontaneous particle-hole symmetry breaking due to the thermal unbalance across the system, considering a specific device geometry. In fact, we demonstrate the feasibility of controlling the device's response by a more convenient "magnetic knob", *i.e.*, exploiting the magnetic

flux through the superconducting ring enclosing one of the junction electrodes. This particular configuration allows the superconducting gap to be independently adjusted by the external magnetic flux. We discuss the peculiar behavior of the quasiparticles current as a function of both magnetic flux and temperatures, with a close look at the main thermoelectric figures of merit of the device. The possibility of controlling the superconducting gap by means of magnetic flux makes it possible for thermoelectric effects to occur even if the two electrodes are formed by the same type of superconductor, thus making the experimental realization of the device much easier, and even to relax the rather tight requirement of fine-temperature tuning.

Semiconductors vs. superconductors: One more case of the "sailing-ship effect"?

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Since superconductivity was discovered, expectations on its use have emerged. An attempted use was that of superconducting computers. In fact, IBM spent huge resources between 1965 and 1983 —when the project was dropped— trying to build a "Josephson computer". The project was abandoned because the incumbent semiconductor technology was being constantly developed. Superconductors' technology is now re-emerging at the core of quantum computers. The uneasy path from the lab to applications is often due to a mix of technical and economic factors. A difficulty in technological substitutions that sometimes emerges is due to the huge intentional improvement of the existing technology as a new one appears —the intentional improvement being addressed as the "sailing-ship effect", named after the battle between the old sail and the new steam-engine technology to provide motion to ships. The sailing-ship effect is thus a mechanism that may prevent a new, superior, technology from substituting an old, less performing, one. In this talk, we apply the sailing-ship effect concept to study, in a mathematical-statistical way, the technological battle between semiconductors and superconductors.

Vortex lattice instability in superconducting materials.

Grimaldi G. ([1]), Leo A. ([1])([2]), Khan M.R. ([1])([2]), Martucciello N. ([1]), Nigro A. ([1])([2])
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Depending on material defects, vortex physics reveals a variety of phenomena that make up a complex magnetic field-temperature phase diagram for superconductors. By driving at high velocities the vortex lattice under current bias its stability can become challenging and in recent years an overall study has been carried out on how to tune this instability by acting on material properties and geometry. In low- high-temperature as well as in Fe-based superconductors, this instability occurs with different features related to the material itself. Nevertheless, a common phenomenological scenario of critical vortex velocities as a function of temperature and magnetic field can be empirically depicted by measurements. Additionally, the size effects have been systematically studied by playing either with a mesoscopic scale or with a nanoscale geometry of samples. We finally draw a reference picture in which by changing width or thickness of sample, temperature and material pinning, anisotropy and angular field orientation as well, it allows for a predictable behaviour of the critical vortex velocity. Our findings unveil unexpected experimental trends within current theoretical frameworks.

Particle-hole spectral asymmetry at the edge of multi-orbital noncentrosymmetric superconductors.

Fukaya Y., Yada K., Tanaka Y., Gentile P., Cuoco M.
CNR-SPIN, c/o University of Salerno, Italy

We demonstrate that in two-dimensional noncentrosymmetric superconductors with multi-orbital spin-triplet pairing the energy profile of the density of states at the edge can be asymmetric. We show that the structure of Andreev reflections generally leads to pairing states made of orbital configurations that are orbitally split due to low crystalline symmetry at the edge. The resulting pairing state has a mixed parity character in the orbital sector that, in the presence of reduced crystal symmetry at the edge, sets out an asymmetric profile for the spectral function. These findings indicate a path to design asymmetric spectral functions at the edge of superconductors with orbital degrees of freedom and time-reversal symmetry. The emerging signatures can be exploited for the detection of spin-triplet pairing equipped with internal degrees of freedom.

Very high field measurements unveil the puzzling behaviour of Fe(Se,Te).

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Fe(Se,Te) is one of the most promising materials to realize devices for high field and high power applications. Anyway, the fundamental nature of superconductivity, as well as some peculiar pinning properties of this material are still puzzling. Here we will present a comprehensive analysis of electrical transport measurements on Fe(Se,Te) thin films grown on CaF_2. We determine the upper critical field and irreversibility field dependence on temperature by angular-dependent magnetoresistance measurements carried out up to 60 T, and down to 1.2 K. A clear crossover between the curves obtained with field applied perpendicular and parallel to the sample *a-b* plane has been found. The existence of this anisotropy crossover has two main consequences. From the point of view of applications, we can identify a temperature range of almost perfectly isotropic superconductivity and pinning. Regarding the fundamental properties of Fe(Se,Te) thin films, the crossover in upper critical field is clear evidence of multiband effects, while the crossover in irreversibility field enlighten the crucial role played by material complex pinning landscape.

InAs nanowire-based field-effect transistors: Temperature dependence of electrical properties and digital applications.

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We report the fabrication, electrical characterization, and digital applications of back-gated

field-effect transistors with a single InAs nanowire as conductive channel at different temperatures. The device shows n-type conduction and high electron mobility. The Arrhenius plot provides the extraction of the Schottky barrier height, whose low value confirms the presence of ohmic contacts between the metal electrodes and the semiconductor nanowire. Three different transport regimes are identified, namely, thermionic emission, tunneling emission, and a crossover regime in which both thermionic and tunneling injections occur. The thermionic mechanism is investigated to extract the subthreshold swing, which becomes lower than 1 V/decade at 200 K, and the density of trap states, which is around $6 \times 10^{12}\,\mathrm{cm}^2\,\mathrm{eV}^{-1}$. Finally, the examined transistor is used as part of a resistive-load inverter. We evaluate the noise margins for the high and low states. Additionally, we test the inverter at 200 K, showing the quite constant gain at both room and low temperature.

Charge and spin transport in ferromagnet-superconductor-ferromagnet heterostructures.

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We study charge and spin transport in ferromagnet-superconductor-ferromagnet junctions. The analysis has been carried out by considering an appropriate generalization of the approach originally introduced by Blonder-Tinkham-Klapwijk for superconductor-normal metal junctions, comparing the effect of different itinerant ferromagnetism mechanisms in the two magnetic leads of the junction. Specifically, we focus on a heterostructure where an antiparallel magnetization is applied between the two ferromagnets. We analyze the scattering processes at the interfaces both for Stoner-like ferromagnets and for spin-bandwidth asymmetry ferromagnets. Then we investigate the conductance and magnetoresistance of this junction and highlight important differences in the behavior of these quantities for the abovementioned ferromagnets. We finally comment on the possible spin valve effects generated within the junction focusing on the effects of the different itinerant ferromagnets.

Curved electronics: Geometry-induced effects at the nanoscale.

Gentile P. ([1]), Cuoco M. ([1]), Volkov O.M. ([1]), Ying Z.-J. ([1]), Vera-Marun I.J. ([1]), Makarov D. ([1]), Ortix C. ([1])
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The growing demand for next-generation electronics providing a link between living matter and the digital world has favored the growth of highly adaptable electronic functional elements capable of recognizing environmental changes by responding to electrical, magnetic, optical and thermal stimuli. The exceptional mechanical properties of these electronic nanomembranes enable further modifications of their structures to yield three-dimensional shapes at the nanoscale and allow configurations that would be impossible to achieve with bulk materials. Such extension in the three-dimensional space provides the means to modify conventional or to launch entirely novel functionalities by tailoring geometric curvature and the three-dimensional shape. The exciting developments in the discovery and exploitation of these novel effects induced by curvature at the nanoscale allow ultimately to define a completely new field —curved nanoelectronics. We here examine in details the origin of curvature effects at the nanoscale and illustrate their potential applications in innovative electronic, spintronic and superconducting devices.

Aula P2 **ore 09:00 – 13:30**

Sezione II
Fisica della materia
Presiede: Paladino E. (Università di Catania)

Relazioni su invito

▲ **Engineering dynamical couplings for quantum thermodynamic tasks.**
Carrega M. (1), Benenti G. (2), Razzoli L. (2), Cangemi L.M. (3), De Filippis G. (3), Cataudella V. (3), Cavaliere F. (1)(4), Sassetti M. (1)(4)
(1) *CNR-SPIN, Genova*
(2) *Center for non linear and complex systems, Dipartimento di Fisica Università dell'Insubria, Como*
(3) *Dipartimento E. Pancini, Università di Napoli Federico II, Napoli*
(4) *Dipartimento di Fisica, Università di Genova, Genova*
Describing the thermodynamic properties of quantum systems far from equilibrium is challenging, in particular when the system is strongly coupled to its environment, or when memory effects cannot be neglected. Here, we address such regimes when the system-baths couplings are periodically modulated in time. We will demonstrate that the couplings modulation, usually associated to a purely dissipative effect can be suitably engineered to perform thermodynamic tasks. We discuss whether, and under which conditions, it is possible to realize a heat engine or a refrigerator. For that purpose, we consider the paradigmatic model of a quantum harmonic oscillator, exposed to a minimal modulation, that is, a monochromatic driving of the coupling to only one out of two thermal baths. We will show that in this setup non-Markovianity of the bath is a necessary condition to obtain a heat engine. In addition, we identify suitable structured environments for the engine to approach the ideal Carnot efficiency. Our results open up new possibilities for the use of non-Markovian open quantum systems for the construction and optimization of quantum thermal machines.

▲ **Quantum coherence and thermodynamics.**
Plastina F.
Dip. Fisica, Università della Calabria; INFN - Gruppo Collegato di Cosenza
Finite-time thermodynamic transformations typically lead to the generation of energetic coherence in the out-of-equilibrium state of a quantum system. In fact, it is possible to identify a contribution to the irreversible entropy production that is due to coherence generation. On the other hand, coherence is connected also to the non-adiabaticity of a processes, for which it gives the dominant contribution for slow-enough transformations. With the help of fluctuation theorems, we will provide a full characterization of the irreversible entropy being generated because of deviation from adiabaticity, and because of coherence production. Furthermore, we will discuss the distinguished role played by initial coherence in the thermodynamics of quantum systems, describing how thermodynamic cycles can be designed to extract work from it.

Comunicazioni

● **Simulation of an entanglement-based quantum key distribution protocol.**
Mariani L. (1)(4), Salatino L. (1), Attanasio C. (1)(2), Pagano S. (1)(2)(3), Citro R. (1)(2)(3)
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Since the '80s when it was first proposed, Quantum Key Distribution (QKD) elicited great interest in the field of cryptography as a unique procedure for key generation that could in principle guarantee unconditionally secure communication by the laws of Physics. In the last fifteen years commercial solutions have started appearing on the market, showing that practical implementations of the protocol were not only possible but also competitive in terms of security and achievable secret-key rate. In this work we describe a simulation of the historical QKD protocol E91 on the *IBM Quantum* platform, making use of the qubit formalism to represent the quantum states received by two communicating nodes. Having implemented also the post-processing steps for the error correction and the privacy amplification, this model can represent a simple stand-alone tool to study the performance of the whole protocol when embedded in more complex structures than one-to-one communication, *e.g.*, in a network environment.

● **The advantages of hyperentanglement in quantum telecommunications processes.**

Salatino L. ([1]), Mariani L. ([1]), Attanasio C. ([1])([2]), Pagano S. ([1])([2])([3]), Citro R. ([1])([2])([3])
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([3]) *INFN, Gruppo collegato di Salerno, Fisciano, Italy*
Entanglement is a very useful phenomenon for quantum information processes. It can be considered as a special case of hyperentanglement, *i.e.*, hyperentanglement with one degree of freedom (DOF). Two particles are hyperentangled if they are entangled in more than one DOF. The main advantage of hyperentanglement is that of being able to encode a greater amount of information by exploiting the DOF of the system. We propose a modelling of a hyperentangled state through copies of a Bell state and evaluate its functionality in a quantum communication protocol. The goal is to simulate the transport of a hyperentangled state through a classical channel in the presence of a system-environment interaction. In particular, we study the trend of the quantum bit error rate (QBER) as a function of the parameters of the Jaynes-Cummings model which simulate the interaction with the environment. By virtue of an increased Hilbert space following the increase in the DOF, the entanglement quantifier, as well as concurrence, decays slower with the distance compared to the case of one DOF.

● **Strategie per la risoluzione del modello di Anderson su quantum computer.**

De Riso G. ([3]), Lo Schiavo M. ([1]), Cipriani F. ([3]), Bisogno V. ([4]), Villani L. ([3]), Romano A. ([1])([2]), Noce C. ([1])([2])
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([4]) *Università degli Studi di Pisa, Pisa, PI, Italy*
I computer quantistici sono dispositivi potenzialmente in grado di risolvere problemi intrattabili con risorse computazionali classiche, tuttavia la loro fabbricazione si è rivelata essere una sfida impegnativa. I prototipi disponibili sono soggetti a varie limitazioni, di conseguenza risulta difficile individuare algoritmi che possano essere efficacemente implementati e in grado al contempo di fornire un vantaggio rispetto un hardware classico. Una classe di algoritmi applicabile ai computer disponibili è data dai Variational Quantum Algorithm

(VQA). A questa classe appartiene il Variational Quantum Eigensolver (VQE), algoritmo ibrido utilizzato per la stima dell'energia del ground state di un sistema fisico. In questa presentazione si applicherà il VQE allo studio del modello di Anderson periodico. Dopo aver presentato gli step necessari all'implementazione dell'algoritmo, quali il mapping fermionico dell'Hamiltoniano e la costruzione degli ansatz variazionali, si discuteranno i risultati ottenuti a seguito di simulazioni effettuate tramite risorse fornite dall'IBM, discutendo le performance degli ansatz scelti per il sistema in esame in ambiente ideale e rumoroso.

Variational quantum algorithms for energy optimization and the thermal-state preparation of a many-body system.

Settino J. ([1])([2]), Plastina F. ([1])([2]), ([1]), Lo Gullo N. ([1])([2]), Mastroianni C. ([3]), Giordano A. ([3]), Vinci A. ([3])([1]), Scarcello L. ([3]), Apollaro T.J.G. ([4])([1]), Consiglio M. ([4]), Lorenzo S. ([4])

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([4]) *Università degli studi di Palermo*

([5]) *University of Malta*

Quantum computing has emerged as a powerful paradigm for solving complex problems that are intractable with classical computers, but limitations of available quantum hardware hinder the use of pure quantum algorithms. In the current "noisy intermediate-scale quantum" (NISQ) era, variational quantum algorithms (VQAs) represent a valid alternative: a set of classically optimized tunable parameters controls the quantum computation. In this presentation, we show how a Quantum Approximate Optimization Algorithm (QAOA) can be used to tackle the NP-Hard prosumer problem, which consists in identifying the most economical combinations for the production, purchase, and sale of energy in a community. Moreover, we develop a VQA for preparing a Gibbs state of a many-body system on a quantum computer, which represents a fundamental ingredient for investigating thermalization and out-of-equilibrium thermodynamics, and providing helpful initial resources for other quantum algorithms. To overtake the constraints of existing hardware, we implement an innovative, efficient, and accurate readout measurement scheme for single- and multi-qubit states, based on Bayesian inference.

Dynamics of open quantum systems: From the quantum Rabi model to coupled qubits.

Di Bello G. ([1]), Cangemi L. M. ([2]), Cataudella V. ([3])([4]), de Candia A. ([3])([4]), De Filippis G. ([3])([4]), Fazio R. ([3])([5])([6]), Nocera A. ([7]), Pavan F. ([1]), Sassetti M. ([8])([9]), Perroni C.A. ([3])

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([7]) *Department of Physics and Astronomy and Stewart Blusson Quantum Matter Institute, University of British Columbia, Vancouver, B.C., Canada*

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Using the worldline Monte Carlo technique, Matrix Product State simulations, and a variational approach, we studied the equilibrium properties and relaxation features of the dissi-

pative quantum Rabi model. This model involves a two-level system coupled to a harmonic oscillator in turn coupled to an Ohmic bath. By adjusting the qubit-oscillator interaction, we proved a Beretzinski-Kosterlitz-Thouless quantum phase transition in low bath coupling. We explored the dynamics of a slow qubit coupled to a fast oscillator and derived functional relationships between them. We examined the effects of internal and external couplings and evaluated the qubit Bloch vector. Interestingly, weak to intermediate bath coupling simplifies qubit state evaluation. In the ultra-strong coupling regime, we observe non-Markovian effects and entanglement growth. Recently, we focus on the effect of baths on other many-body open quantum systems, particularly two interacting qubits in an Ohmic bath. We demonstrate a method for obtaining quasi-fully non-decoherent qubit encoding. Our work sheds light on the behavior of open quantum systems and their potential for quantum computing and quantum communication.

Aula F4 - Henrietta Leavitt **ore 09:00 – 13:30**

Sezione III
Astrofisica
Presiede: Bozza V. (Università di Salerno)

Relazioni su invito

▲ **The Hubble constant tension: new insights from stellar pulsation models.**
Marconi M., De Somma G., Molinaro R.
INAF, Osservatorio Astronomico di Capodimonte
One of the most debated topic in the current astrophysical literature is the discrepancy, at the level of 4 to 6, between the Hubble constant value estimated locally through the SNIa distance scale calibrated with Classical Cepheids and the cosmological value obtained through the study of the Cosmic Microwave Background (CMB) radiation. This is called the Hubble constant tension and represents an important challenge both for cosmologists and for experts of distance indicators. From the local universe point of view, possible residual systematic effects in the calibration of the extragalactic distance scale are invoked as contributors to the tension. In this context current predictions of Cepheid models combined with the most recent Gaia parallaxes are discussed to cast light on the impact of possible variations in physical and chemical parameters of these standard candles.

Comunicazioni

● **An updated theoretical scenario for Classical Cepheids in the Gaia Era.**
De Somma G. ([1])([2]), Marconi M. ([1]), Cassisi S. ([3]), Ripepi V. ([1]), Musella I. ([1])
([1]) *INAF-OAC*
([2]) *INFN-section of Naples*
([3]) *INAF-OAAb*
Modeling of radially pulsating stars, specifically Classical Cepheids, is fundamental for constraining the extragalactic distance scale. The various ingredients entering the theoretical calibration of the CC distance scale can affect the accuracy of the inferred distances and, as such, cast light on residual systematics in the local determination of the Hubble constant in the context of the debated topic known as the Hubble constant tension. By extending the set of nonlinear convective pulsation models published for solar metallicity ($Z = 0.02$, De Somma *et al.*, 2020) to $Z = 0.004$, $Z = 0.008$ and $Z = 0.03$, we provided a detailed homogeneous nonlinear model grid by varying the mass-luminosity (ML) relation, the efficiency of super-adiabatic convection and the chemical composition. As such, a multi-band light curve atlas was produced and period-luminosity-color (PLC), period-Wesenheit (PW) and metal-dependent PW relations for all the assumed assumptions were derived. The derived metal-dependent PW relations were compared with similar results in the literature and applied to a sample of Gaia EDR3 Galactic Cepheids with known metal abundances, so as to estimate their individual distance.

● **Are the Ultra Long Period Cepheids cosmological standard candles?**
Musella I., Marconi M., De Somma G., Molinaro R., Leccia S., Ripepi V., Fiorentino G.
Istituto Nazionale di Astrofisica - Osservatorio Astronomico di Capodimonte e Osservatorio di Roma
Ultra Long Period Cepheids are becoming a very interesting and important topic thanks to the contribution they can give to understanding the current tension existing between the

early-universe and local Hubble constant measurements. These bright pulsating variables are hypothesized to be the counterparts at higher luminosity and mass of the Classical Cepheids. They are observable up to cosmological distances (larger than 100 Mpc) allowing us, in principle, to measure the Hubble constant without the need for secondary indicators, thus reducing the possible systematic errors in the calibration of the extragalactic distance scale. In this paper, the largest known ULP sample, including new possible candidates, is analyzed to give an observational and theoretical overview of their role as distance indicators and of their evolutionary properties.

Stellar pulsation modeling of Classical Cepheids: new determinations of structural parameters and individual distances.

Molinaro R., Marconi M., De Somma G., Ripepi V., Musella I.

INAF-Osservatorio Astronomico di Capodimonte, Napoli

Classical Cepheids are intermediate-mass stars, burning helium in their core, characterized by the presence of radially pulsating motions, which cause their radial dimension to vary periodically, together with their luminosity and temperature. Studying these objects is interesting from two points of view: i) the existence of a correlation between their pulsational period and their luminosity makes them the most used standard candles within the range of standard candles used to calibrate the secondary distance indicators able to reach cosmological distances (above 100Mpc); ii) their pulsational properties make them a perfect "laboratory" to investigate the stellar interiors and to test the theories of stellar structure and evolution. Here, I will discuss the results obtained by comparing the model predictions of a nonlinear convective stellar pulsation code with the light and radial velocity data recently collected within the Gaia mission. Our model fitting technique allows us to estimate the structural parameters (Mass, Temperature, Luminosity) of the investigated Classical Cepheids, together with their individual distances that can be directly compared with Gaia astrometric results.

The YMCA survey: overview and first results.

Gatto M., Ripepi V., Bellazzini M., Tosi M., Chignon M., Dall'Ora M., Tortora C.

INAF, Osservatorio Astronomico di Capodimonte, Naples, Italy

The Magellanic Clouds (MCs) are the Milky Way's most massive dwarf satellites. As they also represent the closest pair of galaxies in an ongoing tidal interaction, while simultaneously infalling into the MW halo, they provide a unique opportunity to study in detail an ongoing three-body encounter. We present the first results from the photometric survey "Yes, Magellanic Clouds Again" (YMCA, PI: V. Ripepi), which covers 110 sq. degrees in the outskirts of the MCs, achieving a photometric depth sufficient to resolve faint, old stellar populations. Overall, the YMCA survey led to some breakthrough outcomes about the past MCs evolutionary life. Our results include the discovery of LMC SCs with ages falling in the so-called age gap, a period almost devoid of SCs, and an old stellar system associated with the LMC, which has structural properties in between the globular clusters and the ultra-faint dwarf galaxies of the Local Group. These findings provide valuable insights into the evolution of the MCs and their intense interaction history, and highlight the importance of detailed photometric studies to uncover the elusive faint and old stellar populations on the outskirts of galaxies.

● **Classical Cepheids as population tracers in the Milky Way and in the Magellanic Clouds.**

Ripepi V.
INAF-Osservatorio Astronomico di Capodimonte

Classical Cepheids (DCEPs) variables are important tracers of the young ($t \sim 50$–300 Myrs) populations in the Milky Way and other galaxies of the Local Group, such as the Magellanic Clouds. In this talk, I present some recent results based on Data Release 3 of the Gaia mission and ground-based photometry concerning the use of DCEPs to trace the Galactic disc and spiral arms and the tridimensional structure of the Magellanic Clouds.

Relazioni su invito

▲ **Multiscale gravitational astronomy in the Gaia era. The Milky Way and its constituents as Einstein's paradigm.**

Crosta M.
INAF-OATo

Highly accurate astrometric measurements in space force fundamental astronomy to move from the classical paradigm, responding to Newton's gravity, to that of Einstein's General Relativity, the current theory of gravity. As a matter of fact, general relativistic models at the very core of Gaia data analysis guarantee the quality of the scientific products that span from the fraction-of-a-parsec scale of the Solar System to the two tens of kpc of that of the Milky Way to comprise, among many others, even fundamental physics tests. With a relativistic-compliant astrometry delivered by Gaia, the question before us is to what extent the reconstruction of our Galaxy, *i.e.*, Gaia's main goal, is dictated by General Relativity or Newton dynamics. The answer would assure a coherent local cosmological laboratory for the predictions of the Lambda-CDM model at the Milky Way scale. Besides that, at the observer's scale, gravitational astrometry offers new tools to observe tiny variations in the fabric of space-time induced by passing gravitational waves, to infer their strength and pinpoint —with unprecedented precision— the direction to the gravitational source for a complete multi-length profile.

Comunicazioni

● **Stars, planets, compact objects and stellar exotica in starburst environment: the EWOCS project.**

Guarcello M.G. for the EWOCS Team
INAF, Osservatorio Astronomico di Palermo

Star formation in our Galaxy typically occurs in environments counting a few 100, 1000 stars. However, a few more extreme star forming environments exist, where hundreds of thousands to millions of stars form in dense regions, often in single events of star formation. Often called starburst regions, they are rare in our Galaxy today, while they are common in galaxies experiencing epochs of intense star formation and in the early Universe. With a distance of 3.87 kpc from the Sun, and an estimated initial mass of 52000 Msol, Westerlund1 is the closest starburst cluster to the Sun. It offers the unique possibility to study star and planet formation, early stellar evolution and compact objects in a starburst environment. In this talk I will present the EWOCS project (Extended Westerlund One Chandra, and JWST, Survey) which is based on a 1Msec Chandra/ACIS-I Large Project, oncoming JWST observations of Westerlund 1, and other optical/infrared data at high spatial resolution (GEMS/GSAOI, HST, etc.). I will discuss the objectives of the project, present the state of the art of data analysis and some preliminary results.

● **Constraining physical processes in local star-forming galaxies using CAMELS cosmological simulations.**

Busillo V. ([1])([2])([3]), Tortora C. ([2])
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([2]) *INAF, Osservatorio Astronomico di Capodimonte, Napoli, Italia*
([3]) *INFN, Sez. di Napoli, Compl. Univ. di Monte S. Angelo, Napoli, Italia*

I will analyze the structural properties and dark matter content of local star-forming galaxies in the mass range $[10^9, 10^{11}]M_\odot$, by comparing the CAMELS cosmological simulations to the observed scaling relations from the SPARC sample. The relations considered are the correlations of size, internal dark matter fraction, internal dark matter mass and total mass with total stellar mass. I will explain how these relations can be used to constrain cosmological and astrophysical parameters, by searching for the combination which minimizes the χ^2 evaluated with respect to the observations. For the IllustrisTNG suite, we find results consistent within 1σ with the nine-year WMAP observations. Results for the supernovae feedback parameters indicate that simulations with lower outflow wind energy per unit SFR better reproduce the observations. AGN feedback parameter variations show negligible effects on the trends within the mass range considered. For the SIMBA suite, simulations predict large central dark matter mass, with trends reconciliable with observations only by using parameter values which are inconsistent with most observational constraints.

Relazioni su invito

▲ **The Vera C. Rubin Observatory Legacy Survey of Space and Time and the Italian participation to the project.**

Raiteri C.M.
INAF, Osservatorio Astrofisico di Torino

The Vera C. Rubin Observatory Legacy Survey of Space and Time (Rubin-LSST) is expected to revolutionize many fields of Astrophysics. The project will be accomplished with a 8.4 m telescope with a field of view of 9.6 square degrees located in Cerro Pachón (Chile). The main survey will scan about 20000 square degrees of the southern sky for ten years in six optical bands (u, g, r, i, y, z) with a cadence of a few days. The main objectives are: i) probing the distribution of dark matter and measuring the effects of dark energy; ii) exploring the transient and variable universe; iii) studying the structure of the Milky Way galaxy and its neighbors; iv) making an inventory of the Solar System. The preparatory work to maximize the scientific return of the Rubin-LSST data is carried out within eight Science Collaborations. There is a wide interest of the Italian research community in Rubin-LSST. More than 100 Italian scientists have acquired data rights through the Italian in-kind contribution program led by INAF, which includes support to the commissioning activities, software development, provision of external data, and the use of the 2.61 m VLT Survey Telescope (VST).

Comunicazioni

● **Detection of slow-moving objects with LSST.**

Vanzanella A. ([1]), Inno L. ([1])([2]), Daylan T. ([3]), Bertini I. ([1])([5]), Fulle M. ([4]), Rotundi A. ([1])([5]), Fiscale S. ([1]), Della Corte V. ([2]), Mazzotta Epifani E. ([6]), Piccirillo A.M. ([1]), Tubiana C. ([5]), Ammannito E. ([7]), Sindoni G. ([7])
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([7]) *ASI, Roma, Italy*

The Legacy Survey of Space and Time (LSST) will start running in 2025, spanning a decade, and will provide an unparalleled catalog of celestial objects observable from the Southern Hemisphere. Faint and distant objects will pose a challenge for the automated pipelines, and we want to improve our detection chances for these targets by using Machine Learning. To this purpose, we developed a binary classifier of slow-moving objects (SMOs) in LSST images by training a three-dimensional Convolutional Neural Network (CNN). As the survey has yet to commence, we have used simulated data, provided by the Dark Energy Science Collaboration, where we have injected simulated SMOs to create the training set. The simulated SMOs have been generated using the ephemeris of Trans-Neptunian objects and scaled to greater distances. We evaluated the network performance on an independent, smaller test set and found an accuracy of 90%. We are now investigating how the CNN performs as a function of the luminosity and apparent speed/orientation of the target SMOs.

● **Kilonova parameters estimation with LSST at Vera C. Rubin Observatory.**

Ragosta F. ([1]), Ahumada T. ([2])([3])([4]), Andreoni I. ([2])([3])([5]), Piranomonte S. ([1]), Colombo A. ([6])([7]), Salafia O. S. ([6])([7])([8])
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([7]) *INFN, Sezione di Milano-Bicocca, Milano, MI, Italy*
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Kilonovae (KNe) are rare events that occur when unstable heavy isotopes undergo radioactive decay after synthesis by the rapid neutron capture in the ejecta. To decode the informations form transients' feature, which could provide insight into the merger dynamics and the neutron star matter equation of state (EoS), we need to compare models with the data. In this study, we aim to test the possibility of using Vera C. Rubin Observatory (VRO) photometric observations within the Legacy Survey of Space and Time (LSST) to constrain the mass and velocity of different KN ejecta components. We used a sample of simulated light curves and applied several observational constraints to produce observed light curves and to study how strategies' choice impact parameters' estimation. We found that the observing strategy design to be the best compromise between light curves coverage, observed filters and fit reliability involves a high number of visits with long gap pairs of about 2 hours every 2 nights in the same or different filters. These features of the observing strategy will allow us to recognize the different stages of light curve evolution and gather observations in at least 3 filters.

Relazioni su invito

▲ Opening the time domain for Supermassive Black Hole studies across the Universe.

Paolillo M.
Dipartimento di Fisica Ettore Pancini, Università Federico II di Napoli, Italia, INAF, Osservatorio di Capodimonte, Napoli, Italia e INFN, Sezione di Napoli, Italia

Timing studies have been one of the main tools by which we inferred the presence of Supermassive Black Holes (SMBH) in the center of Galaxies, and they provided crucial insights into the structure of accreting sources (*i.e.*, Active Galactic Nuclei). Variability studies have now expanded to a new dimension, with both large and deep surveys probing the time domain in order to obtain a census of SMBH in the Universe. I will describe some of the efforts done in the last two decades to detect and characterise AGN through variability both in the X-ray and in the optical, as well as the expectations from upcoming next generation surveys such as eRASS and LSST.

▲ Comets: Vera Rubin LSST survey to search for the ESA/Comet Interceptor target.

Inno L. ([1])([2]), Bertini I. ([1])([3]), Fulle M. ([4]), Rotundi A. ([1])([3]), Vanzanella A. ([1]), Fiscale S. ([1]), Della Corte V. ([2]), Mazzotta Epifani E. ([5]), Piccirillo A.M. ([1]), Tubiana C. ([3]), Ammannito E. ([6]), Sindoni G. ([6])
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Comet Interceptor (CI), the first selected ESA F-class mission, will be launched in 2029 and break many records: 1) it will be the first space probe to perform a close flyby of a pristine Long Period Comet (LPC) or an interstellar comet; 2) it will be designed and possibly launched before its target is even known; 3) it will comprise three spacecraft, adding multi-dimensionality to the information gathered by the onboard instruments. CI will be parked at the stable Lagrange point L2 for about 2 years, waiting for the discovery of a suitable target that will be intercepted close to the ecliptic plane. Such a challenging strategy will be feasible with the support of the Legacy Survey of Space and Time (LSST) that will be carried out by the Vera C. Rubin Observatory, in Chile. LSST, a deep, time-resolved 10-year survey of the entire southern sky, will be the best equipped facility for early detection of CI potential targets. In this talk, I will present the LSST survey and the ongoing work that I am leading in the framework of the Solar System Science Collaboration to prepare for Comet Interceptor.

▲ The search for life on Mars.

Fornaro T.
INAF-Osservatorio Astrofisico di Arcetri

The past and current exploration missions of the planet Mars have by now ascertained its past habitability, *i.e.*, Mars possessed the geochemical complexity necessary to sustain life. The most compelling question to address next is: has life ever emerged or thrived in such habitable environments on Mars? To answer this question, the NASA Mars 2020 Perseverance rover is currently operating at the Jezero crater on Mars, analyzing and collecting astrobiologically

relevant rocks for future return to Earth. The main criterion to assess the astrobiological relevance of a Martian sample is the presence of minerals characterized by high biosignature preservation potential and organic matter. In this contribution, the most recent results from Perseverance will be reviewed and the plans for the future ESA ExoMars mission and NASA-ESA Mars Sample Return campaign will be presented.

Comunicazioni

● **Commissioning and first scientific results of the LOCNES solar telescope.**

Cabona L. ([1]), Claudi R. ([1]), Ghedina A. ([2]), Pace E. ([3]), Liu S.J. ([4]), D'Orazi V. ([1]), Rainer M. ([5]), Guglielmino S. ([6]), Harutyunyan A. ([2])
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LOCNES (LOw-Cost NIR Extended Solar telescope) is a solar telescope installed at the TNG (Telescopio Nazionale Galileo). It feeds the NIR spectrograph GIANO-B with light from the Sun. LOCNES has been designed to obtain high signal-to-noise ratio spectra of the Sun as a star with precise wavelength calibration using molecular-band cells. This is a completely new area of investigation that will provide timely results to improve the search for telluric planets. We will extract several disk integrated activity indicators and mean magnetic field measurements for the Sun in the NIR. This spectral region will sample different layers of the solar atmosphere down to the lowest accessible level at 1600 nm, where continuum opacity is at its minimum. Molecular features should correlate with sunspots passing across the solar disk, while the chromosphere would be monitored by the He I 1083 nm line. Such an approach will allow a better understanding of the origin of activity-induced RV variations and will help to improve the techniques for their correction. With this communication we outline the scientific drivers for the LOCNES project and its first commissioning and scientific results.

● **Stato di DAMA/LIBRA.**

Leoncini A. ([1])([2]), Belli P. ([1])([2]), Bernabei R. ([1])([2]), Cappella F. ([3])([4]), Caracciolo V. ([1])([2]), Cerulli R. ([1])([2]), Dai C.J. ([5]), D'Angelo A. ([1])([2]), Incicchitti A. ([3])([4]), Ma X.H. ([5]), Merlo V. ([1])([2]), Montecchia F. ([2])([6]), Sheng X.D. ([5]), Ye Z.P. ([5])([7])
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L'apparato sperimentale DAMA/LIBRA-fase2 (circa 250 kg di NaI(Tl) altamente radiopuro) opera presso i Laboratori Nazionali del Gran Sasso dell'INFN. In questa comunicazione saranno presentati i risultati recenti e sarà discussa la configurazione potenziata dell'apparato attualmente in misura con lo scopo di studiare eventi ad energie al di sotto della soglia software di 1 keV.

Aula F3 - Maria Telkes **ore 09:00 – 13:30**

Sezione IV
Geofisica e fisica dell'ambiente
Presiede: Serva F. (ISMAR-CNR, Roma)

Relazioni su invito

▲ **A network of water vapor Raman lidars to improve heavy precipitation forecasting in southern France in the frame of WaLiNeAs: Several months of continuous operation of two Italian systems.**
Di Girolamo P. ([1]), Franco N. ([1]), Di Paolantonio M. ([1])([2]), Summa D. ([1])([2]), Dionisi D. ([3]), Madonna F. ([4]), Rosoldi M ([2]), Di Bernardino A. ([5]), Iannarelli A.M. ([6]), Di Iorio T. ([7])
([1]) *Scuola di Ingegneria, Università degli Studi della Basilicata*
([2]) *IMAA-CNR*
([3]) *ISMAR-CNR*
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([5]) *Dipartimento di Fisica, Università degli Studi di Roma Sapienza*
([6]) *SERCO-ESA/ESRIN*
([7]) *ENEA Centro Ricerche Casaccia*
The Raman lidars CONCERNING and MARCO were deployed in Southern France in the frame of the Water Vapor Lidar Network Assimilation-WaLiNeAs experiment. WaLiNeAs is an international field experiment aimed at studying extreme precipitation events and improving their predictability through the assimilation into mesoscale numerical models of water vapour profile measurements from a network of Raman lidar systems. CONCERNING (COmpact RamaN lidar for Atmospheric CO_2 and ThERmodyNamic ProfilING) and MARCO (Micropulse Atmospheric Optical Radar for Climate Observations) are two compact and transportable Raman lidar systems designed for long-term all-weather continuous operation, capable to measure high-resolution and accurate CO_2 and water vapour mixing ratio profiles, together with temperature and multi-wavelength particle backscatter/extinction/depolarization profiles. CONCERNING was deployed at the Univ. of Toulon (La Garde), with continuous measurements from 29 September 2022 to 25 January 202, while MARCO was deployed in Port-Saint-Louis, with continuous measurements since 19 October 2022. Results from these two systems and from the project will be illustrated at the Congress.

▲ **Improvement of temperature and humidity quality from RALMO and experiments towards operational assimilation.**
Martucci G., Haefele A., Crezee B., Leuenberger D.
Federal Office of Meteorology and Climatology MeteoSwiss
An overview of the transceiver system of the Raman Lidar for Meteorological Observation (RALMO) is provided along with the procedure to define the different error contributions stemming from RALMO acquisition system and from the atmospheric disturbances to the measured signal. The systematic and random error components are combined into the overall error of the retrieved humidity (q) and temperature (T) products. The overall T and q errors are validated via direct comparison with co-located Vaisala RS41 radiosounding at 23:00 UTC. A 13-month validation of q and T profiles is also performed by direct comparison

with the Vaisala RS41 at 11:00 and 23:00 UTC. The comparisons shows the mean bias and standard deviation of the differences $T_{RAL} - T_{RS41}$ and $q_{RAL} - q_{RS41}$. The mean bias is consistent with the zero-bias for both daytime and nighttime statistics for both T and q. The validated T_{RAL}, q_{RAL} and their related errors, have been assimilated into the COSMO-1E model for dedicated experiments demonstrating a clear positive impact for total precipitation forecasts at different lead times. The T and q from RALMO are ready for operational assimilation into COSMO-1E.

▲ **Lesson learnt from the OPERANDUM project: A novel framework for hydro-meteorological risk reduction using nature-based solutions.**
Di Sabatino S., Brogno L., Barbano F., Ruggieri P., Leo L.
Department of Physics and Astronomy "Augusto Righi", University of Bologna
Hydro-meteorological risks (HMR) such as river flooding, coastal erosion, salt intrusion are becoming more and more damaging due to climate change. The impact of HMR is expected to lead to relevant economic losses and additional CO_2 emissions affecting resilience and exacerbating in turn climate change. In this communication we will discuss the lesson learnt from the project H2020 OPERANDUM to demonstrate the ability of nature-based solutions (NBS) to reduce hydro-meteorological risks. In this context a novel framework for the assessment of risks resulting from heat waves with the aim of quantifying the main contributions to economic losses and CO_2 emissions is presented. The formulation of the framework includes the the description of the NBS, used to enhance our adaptive capacity in a sustainable and cost-effective way. Since NBS consist of natural features that are also exposed to heat waves, the entire life cycle of NBS is considered (*i.e.*, the implementation, maintenance, and possible restorations). The proposed framework stands as a tool for assessing the local impacts of already implemented or designed NBS in the current and future climate scenarios.

Comunicazioni

● **Comparison of surface shortwave and longwave fluxes at the Thule High Arctic Atmospheric Observatory, Greenland, with CERES products.**
Meloni D. ([1]), Calì Quaglia F. ([2])([3]), Ciardini V. ([1]), Di Bernardino A. ([4]), Di Iorio T. ([1]), Iaccarino A. ([1]), Muscari G. ([3]), Pace G. ([1]), Scarchilli C. ([1]), di Sarra A. ([5])
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Determination of shortwave (SW) and longwave (LW) radiation from space is fundamental in regions where few surface observations are available. This is particularly important in the Arctic due to the complex feedback mechanisms affecting climate in this region. Few sites located in the Arctic region provide surface radiation flux (SRF) measurements long enough to conduct systematic comparisons with satellite products. Long-term measurements of downward and upward SW (DSI and USI) and LW irradiances (DLI and ULI) are carried out at the Thule High Arctic Atmospheric Observatory (THAAO, 76.5° N, 68.8° W), in North-Western Greenland. DSI and DLI measurements were started in 2009, and USI and ULI in 2016. In this analysis the four SRF components have been compared with Level 3 Clouds and the Earth's Radiant Energy System (CERES) surface products, to assess the

agreement between ground-based and satellite-derived radiation data. On a monthly basis the comparison shows good agreement, with mean negative bias of -4.4 Wm^{-2} for DSI (CERES data underestimates *in situ* ones), and a mean positive bias of 2.3 Wm^{-2} for DLI, possibly associated to cloud effects.

Assessment of formulas for clear sky downwelling longwave irradiance in the Arctic.

Pace G. [1], Calì Quaglia F. [2][3], Ciardini V. [1], Di Bernardino A. [4], Di Iorio T. [1], Iaccarino A. [1], Meloni D. [1], Muscari G. [3], Scarchilli C. [1], di Sarra A. [5]

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Ground-based high-resolution observations of downward longwave irradiance (DLI), surface temperature, water vapour surface partial pressure and column amount and zenith sky infrared radiance in the atmospheric window are regularly obtained at the Thule High Arctic Atmospheric Observatory (THAAO, 76.5°N, 68.8°W), North-West Greenland. These datasets from 2017 and 2018 are used to assess the performance of different empirical formulas to infer clear sky DLI. Seventeen different formulas to estimate DLI have been tested against the THAAO dataset, using the originally determined coefficients. Formulas which combine information on total column water vapour and surface temperature appear to perform better than others, with a mean bias with respect to the measured DLI smaller than 1 W/m^2 and a root mean squared error around 6 W/m^2. The bias displays a significant improvement when the coefficients of the different formulas are calculated using the THAAO dataset. The presence of two full years of data allows the investigation of the inter-annual variability, and the use of different years for the determination of the coefficients and the evaluation of results.

Cloud optical thickness retrievals in the Arctic from zenith-looking spectral measurements.

Calì Quaglia F. [1][2], Meloni D. [3], Muscari G. [2], Di Bernardino A. [4], Di Iorio T. [3], Pace G. [3], Schmidt S. [5], di Sarra A. [6]

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Clouds are one of the Earth system components which need to be comprehensively understood and from which most of the uncertainties in climate models and forecasts originate. Cloud Optical Thickness (COT) is of utmost importance for estimating the effects of clouds on the upwelling and downwelling radiation. Still, few issues arise when retrieving it over high albedo surfaces from ground-based or satellite measurements. We used a mixed approach

that combines radiative transfer model simulations (libRadtran v. 2.0.4) with ground-based zenith spectral measurements (310–950 nm) at the Thule High Arctic Atmospheric Observatory (THAAO 76.5° N, 68.8° W, Greenland) to estimate COT. We present the theoretical background and the application of different algorithms for COT retrievals in low- and high-surface albedo conditions for liquid water clouds and homogeneous cloud cover. We compare various spectral algorithms for COT with retrievals relying on the instruments available at THAAO. In the case of high-surface albedo, we find good agreement among the methods when using spectral algorithms that include external information on the cloud base height.

Land-sea breeze in a coastal site in the central Mediterranean: Observations and analysis.

Gandolfi I. (1), Madonna F. (1)(2), Rosoldi M. (1), Summa D. (1), Gagliardi S. (1), De Rosa B. (1)

(1) *National Research Council of Italy-Institute of Methodologies for Environmental Analysis, CNR-IMAA*

(2) *Department of Physics "E.R. Caianiello", University of Salerno*

In a global warming scenario, the study of local atmospheric circulation is key for implementing adaptation strategies mitigating the effect of temperature extremes. In this context, wind dynamics in the coastal site of Soverato in the central Mediterranean have been investigated, using the wind data collected during the MESSA-DIN (MEditerranean Sea Salt And Dust Ice Nuclei) campaign, carried out by CNR-IMAA from June to November 2021. The variability of land-sea breezes and local wind dynamic for the Soverato site is discussed considering the role of Saharan dust outbreaks, marine aerosol transport and synoptic circulation. The evolution of the breeze dynamic at the site in relationship with the reanalysis data of summer heatwaves is also investigated.

Latent flow measurement by Wind Lidar and Raman Lidar during WaLiNeas campaign.

Summa D. (1), Di Girolamo P. (2), Franco N. (2), Gandolfi I. (1), Di Paolantonio M. (3), Rosoldi M. (1), D'Amico G. (1)

(1) *CNR-IMAA*

(2) *Università della Basilicata*

(3) *CNR-ISMAR*

The Measure Walines campaign (Lidar Network Assimilation) was born with the aim of being able to improve the prediction of heavy rainfall in the Mediterranean Sea. It was designed with the aim of providing water vapor measurements with high resolution and spatio-temporal accuracy, in order to be assimilated into the AROME mesoscale model using a four-dimensional ensemble variational approach with 15-minute updates. The instruments used in this campaign were The CONCERNING Lidar of the University of Basilicata and a Wind Lidar of the CNR-IMAA which were co-located at the University of Toulon between October 2022 and January 2023 to achieve the campaign goal. For this purpose vertical latent heat flux profiles were calculated as covariance matrices from the vertical wind component (w'') and the mixing ratio (q'') estimated as retrieval of Wind Lidar and Raman Lidar UV data, respectively. A time series of vertical wind profiles of the selected case (October 31 to November 3) are calculated. The pecific humidity flux $\langle w''q'' \rangle$ [g/kg∗m/s] is converted into latent heat flux (W/m^2). The results will be presented during the Congress.

Ground-based remote sensing observations of aerosols and clouds above a coastal site in the Central Mediterranean.

Rosoldi M. (1), Gandolfi I. (1), Summa D. (1), De Rosa B. (1), Cvetkovic B. (2), Nickovic S. (2), Madonna F. (1)(3)

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Aerosols affect clouds microphysical and macrophysical properties, precipitation efficiency and, ultimately, clouds radiative effects. Aerosol-Cloud Interactions (ACI) are not well quantified and modeled, representing one of the most uncertain contributions to the Earth's radiation budget. Ground-based remote sensing observations can contribute to improve ACI understanding and models representation because of their ability to observe co-occurring aerosols and clouds through the troposphere. Such an observational dataset was collected during the MESSA-DIN (MEditerranean Sea Salt And Dust Ice Nuclei) campaign, with a particular focus on the role of mineral dust and marine aerosol. The campaign, organized by the CNR-IMAA, was carried out at the coastal site of Soverato, in the Central Mediterranean. An overview of the campaign, involved instruments and data analysis is presented. Case studies on clouds formation in the presence of dust and marine aerosol are discussed, including the comparison of observational products with those of a regional atmospheric model coupled with transport models and heterogeneous ice nucleation parameterizations specific for both dust and marine aerosol.

Notes on the quality of in situ data.
Tramutola E., Marra F., Madonna F.
Consiglio Nazionale delle Ricerche-Istituto di Metodologie per l'Analisi Ambientale, CNR-IMAA
The recent increase in the amount and type of climate measurements has improved our knowledge of the Earth system and the quality of the reanalysis data. Nevertheless, the huge amount of high-resolution data, in time and space, requires a rigorous quality assurance system able to identify issues in the data and reduce the negative effect of wrong or low-quality data that may have an impact the data analysis. In the frame of Copernicus Climate Change Service (C3S), several datasets covering different essential climate variables are provided: these datasets are made available by networks and international measurement programs, running at the global scale, and may include added-value products elaborated upon them. The effort spent within the activities implementing the C3S *in situ* component allowed the identification of corrupted or anomalous data, despite routine quality checks applied by the data providers. This communication will discuss the lesson learned during the data-checking of a few *in situ* datasets available in the CDS, with a few examples also used to interact with the data providers and improve both the source data and C3S products.

Sensibilità e incertezza di modelli di assorbimento atmosferico per la simulazione di osservazioni satellitari a microonde.
Cimini D. ([1])([2]), Gallucci D. ([1]), Larosa S. ([1]), Romano F. ([1])
([1]) *Consiglio Nazionale delle Ricerche - Istituto di Metodologie per l'Analisi Ambientale, Potenza, Italia*
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I sensori radiometrici a microonde su satellite forniscono il maggior contributo informativo tra le osservazioni della Terra assimilate nei modelli di previsione meteorologica e nelle reanalisi climatologiche. Tale contributo passa attraverso l'applicazione di modelli diretti di assorbimento atmosferico, la cui incertezza non è nota a priori. Questa comunicazione presenta un approccio generale per quantificare l'incertezza dei modelli di assorbimento atmosferico partendo dall'incertezza sui parametri spettroscopici utilizzati. L'approccio è applicato ad

un modello di assorbimento a microonde nell'intervallo 16–700 GHz, utile per il sondaggio atmosferico mediante radiometria a microonde da terra e da satellite. L'analisi di sensibilità mostra che dei 2260 parametri considerati, 135 risultano dominanti. Per questi è stato calcolato l'impatto dell'incertezza sulle simulazioni di osservazioni satellitari in diverse zone climatiche. Tali risultati contribuiscono alla caratterizzazione di sensori di nuova generazione che saranno a bordo della missione European Polar Satellite - Second Generation dell'agenzia europea per l'utilizzo dei satelliti meteorologici (EUMETSAT) dal 2024 in poi.

Aumento della risoluzione spaziale delle previsioni meteorologiche mediante algoritmo a reti neurali per applicazioni in agricoltura di precisione.

Di Paola F., Cimini D., De Natale M.P., Gallucci D., Gentile S., Geraldi E., Larosa S., Nilo S. T., Ricciardelli E., Romano F., Viggiano M.

Consiglio Nazionale delle Ricerche, Istituto di Metodologie per l'Analisi Ambientale, Tito Scalo, PZ, Italia

Nell'ambito del progetto On Demand Services For Smart Agriculture (OD4SA), finanziato dal PO FESR 2014–2020 della regione Basilicata, è stato sviluppato un servizio di previsione meteorologica ad alta risoluzione spaziale per l'agricoltura di precisione, che fornisce quotidianamente previsioni orarie, per le successive 96 ore su un'area di circa (480×380) km^2 nel Sud Italia, della temperatura e del rapporto di mescolanza del vapore d'acqua a 2 m di altezza, delle componenti zonale e meridionale del vento a 10 m di altezza, della pressione atmosferica superficiale, dell'irraggiamento solare e della precipitazione cumulata oraria. Il servizio si basa sugli output del modello di previsione meteorologica Weather Research and Forecasting (WRF) Advanced Research core, che mediante un algoritmo a reti neurali sono portati dalla risoluzione spaziale orizzontale iniziale di 1.2 km alla risoluzione spaziale di 240 m. Le reti sono state addestrate su un database elaborato con lo stesso modello WRF, utilizzato in modalità Large Eddy Simulation per risolvere esplicitamente i processi turbolenti nello strato limite planetario e consentire di raggiungere la scala sub-chilometrica.

Thermodynamic and metrological issues in environmental measurements.

Coppa, G. ([1]), Musacchio, C. ([1]), Merlone, M. ([1])([2])([3])

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Environmental measurements represent a phenomenal societal and scientific challenge of ever-growing importance in the light of the ongoing and future climate variability. Thermal quantities (air, sea, snow and soil temperature, humidity, permafrost depth) are key among the Essential Climate Variables (ECVs) as defined by the WMO Global Climate Observing System in these areas. In order to accurately capture climatic trends and enable early detection, metrological rigor in terms of sensor calibration and uncertainty budget evaluation are of paramount importance. For this reason, the metrology and meteo/climatic communities have started a decade-long ongoing cooperation through the mutual recognition accords between the WMO and BIPM, which led to the exchange of representatives in WGs, the cohosting of a series of joint workshops ("Metrology for Climate Action"), and a general strict cooperation, through the development of new measurement techniques and instruments; the understanding of uncertainty components both for laboratory calibration and for field conditions; the accurate evaluation of quantities of influence; and the development guidelines, best practices and recommendations.

A nextgen LP-IoT weather station.

Vitali G., Magnanini E.
University of Bologna

IoT is changing the way of making measurements and observing the environment, and overall to strongly decrease costs making everybody able to assemble a variety of new devices based on reliable components. Besides the growing interest in remote sensing, and standardised terrestrial weather stations, affected by high maintenance costs new cross-discipline approaches are blooming. A representative case is given by a new weather station, where off-the-shelf sensors are used to realise a low-maintenance and durable station including temperature, relative humidity, pressure, radiation, wind velocity and direction together with a disdrometer for characterising rainfall events, the latter being of particular interest in the extreme event scenario. Former performances and calibrations are described, showing how the range of measure, though not comparable to the majority of standard weather stations, its LP-IoT approach, ensuring autonomous power supply and real-time data availability, may be useful in several investigations in the domains of applied atmosphere physics and hydrology.

Background and observation error covariance matrices information in the physical nudging equations.

Conti G.
Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici CMCC, CSP division, Bologna

In this contribution we show how to extend the deterministic physical nudging scheme in order to include two important ingredients, the background and observation error covariance matrices, that are common features of classical data assimilation schemes. The derivation exploits the relation between the Langevin and Fokker-Planck equations to formulate the data assimilation problem and retrieve the assimilation scheme in coordinate space. The background, **B**, was naturally introduced noticing the role of the diffusion matrix in the Fokker-Planck equation related to the noise modulation in the correspondent Langevin equation. The observation error covariance matrix **R** was introduced solving a Kolmogorov backward problem related to our formulation noticing that the final condition, instead of being considered as a Dirac δ function, could be simply represented by a Gaussian function with a covariance matrix corresponding to **R**. In this way the initial and final conditions of the DA problem are treated dynamically.

Exploring the potential of artificial intelligence in volcanic hazard monitoring from space.

Cariello S. ([1])([2]), Torrisi F. ([1])([2]), Corradino C. ([1]), Del Negro C. ([1])
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([2]) *Università degli Studi di Catania, Dipartimento di Ingegneria Elettrica, Elettronica e Informatica*

Operational monitoring centers like the Etna Volcano Observatory (EVO) are nowadays heavily reliant on remote sensing data from a variety of optical and thermal sensors to provide time-critical hazard information. The huge amount of satellite data available requires new approaches capable of processing them automatically and artificial intelligence (AI) addresses these needs. Here, an AI-based platform was developed to monitor in near real-time the volcanic activity from space. AI algorithms are used to retrieve information about the ongoing volcanic activity. Under this perspective, a key role is played by Machine Learning since it overcomes the issues related to hard coded/explicit rules by implicitly learning them from historical satellite data. Volcanic eruptions are then fully characterized estimating the thermal energy release and quantifying the erupted products. This task is achieved

by combining a variety of multispectral satellite datasets, ranging from visible to infrared and radar, with different spatial and temporal features. We explore the potential of this web-based satellite-data–driven platform during the recent eruptive events on Stromboli and Etna volcanoes.

Aula F7 - Giovanna Mayr **ore 09:00 – 13:30**

Sezione V
Biofisica e fisica medica
Presiede: Marchetti M.L. (Università di Parma)

Relazioni su invito

▲ **Nano- and microfabrication for biomimetics and cell control: spinning, molding, printing, and more.**
Pisignano D. ([1])([2])
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([2]) *Istituto Nanoscienze-CNR, Italy*
Micro- and nano-surface topographic cues are important for a variety of applications in biophysics and biotechnologies. Patterns of nanostructures might guide living cells in positioning, proliferating and functioning. Intelligent surfaces encompassing stimuli-responsive materials can sense and respond to external changes in cellular or other biological environments. The continuous development of high-throughput nano- and microfabrication technologies, specifically addressing and enhancing the physico-chemical properties of biologically-relevant materials, is crucial to support advances of life-sciences and biotechnology. Here we present a multi-tool platform for realizing complex nano- and micro-topologies applying to bio-sciences. Applications include surface-controlled differentiation in stem cells, piezoelectric devices for health-monitoring, time-temperature and smart indicators for environmental tracking. We acknowledge the support of the Italian Minister of Research (PRIN 2017PHRM8X) and of the European Union by the Next Generation EU project ECS00000017 “Ecosistema dell’Innovazione” Tuscany Health Ecosystem (Spoke 4: Nanotechnologies for diagnosis and therapy).

▲ **Chirality amplification in spherically confined chromonics.**
De Santo M.P. ([1])([2]), Spina L. ([1])([2]), Tone C.M. ([1])([2]), Barberi R. ([1])([2]), Ciuchi F. ([2])
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Induced or spontaneous chirality in natural systems is an intriguing issue. In recent years, a lot of attention has been focused on chirality of chromonic liquid crystals, a class of materials that is able to self-assemble in columnar structures, one typical example is DNA. The reflection symmetry breaking observed in chromonic liquid crystals confined in curved geometries, like tactoids, microspheres or capillaries, has been the focus of constant investigations. This spontaneous twist may be enhanced by doping nematic chromonics with L and D peptides. However, the mechanism involved in the arising of chirality, that starts at the molecular level and controls the supramolecular structure, is poorly understood. Here, we report on the possibility to obtain, in microspheres of chiral induced chromonics embedded in a polymeric matrix, well-defined optical textures indistinguishable from the ones obtained in chiral thermotropic liquid crystals. This result is not obvious since we are dealing with three components systems whose time stability is a delicate thermodynamic balance. An application as biocompatible time temperature indicators is also proposed.

▲ **3D bioprinting of reliable tumor models to test photothermal/photodynamic therapies.**

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Bioprinting of tumor models is rapidly becoming an essential tool for testing novel cancer therapies. Photothermal therapy is a promising therapeutic/supportive approach to treating cancer by using light-absorbing materials to generate heat and destroy tumor cells. However, the efficacy of this therapy heavily relies on the accurate and reliable modeling of tumors *in vitro*. Bioprinting offers the ability to create complex, multicellular tumor models that mimic the *in vivo* tumor microenvironment. Moreover, bioprinting has the advantege of potentially testing therapies directly on patient's derived cells, not having to deal with the different physiology of animal models. This technology involves the precise positioning of cells and biomaterials to replicate the architecture and function of the tumor. Here, we tested the effectiveness of photothermal/photodynamic therapy alone or in combination with standard approaches, such as chemotherapy or immunotherapy on several bioprinted tumor models. This will contribute to deepening knowledge in oncology, shortening the path to clinical translation.

Comunicazioni

● **Magnetic and biophysical characterization of nanoparticles for photodynamical therapy on in vitro silico model.**

Catalano E.

Sant'Anna School of Advanced Studies, Pisa, Italy

Effective drug delivery and targeted nanophysics applications require a deep understanding of the biophysical and magnetic interactions between nanoparticles (NPs) for photoinduced tumor destruction. Recent advances in nanomedicine can be applied to create an *in vitro* system that mimics tumor behavior. Iron oxide and other NPs offer potential as a diagnostic tool, as well as a means for magnetic hyperthermia. In this study, we developed polyethylenimine-conjugated superparamagnetic iron-oxide nanoparticles (SPIONs) to target the delivery of chemotherapeutics and photodynamic therapy in an *in vitro* silico model. A photosensitizer (PS) can absorb photon of light and transform from a ground state to an excited state. The excited PS can either decay back to the ground state through fluorescence, which enables photodetection, or it can transform into the relatively longer-lived triplet state through intersystem crossing. We assembled a multi-functionalized nanoparticle by allowing doxorubicin to adsorb onto polyeth-ylenimine-iron oxide nanoparticles through electrostatic reaction. The drug-coated particles initially inhibited growth and proliferation of resistant cancer cells *in vitro*.

● **Nanoparticelle magnetiche di differente forma e dimensione: effetto sulle proprietà rilassometriche e ipertermiche.**

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In nanomedicina le nanoparticelle (NP) magnetiche sono impiegabili in ambito diagnostico e terapeutico, rispettivamente come agenti di contrasto nell'imaging a risonanza magnetica e agenti ipertermici antitumorali. L'obiettivo di questo lavoro è capire come caratteristiche morfostrutturali quali forma e dimensione possano influenzare le proprietà magnetiche e rilassometriche delle NP, per ottimizzarle in base al campo di applicazione. Abbiamo investigato 3 set di NP a base di ossidi di ferro di diversa forma (sfere, flowers e cubi) e dimensione (6–35 nm), rivestite con diverse molecole biocompatibili (DMSA, PAA e CM-Dextran). Dopo l'analisi morfostrutturale (TEM, XRD, IR, TG, DLS e VSM) sono state indagate le proprietà rilassometriche acquisendo i profili NMRD, rappresentativi della rilassività nucleare longitudinale e trasversale in funzione della frequenza (campo magnetico statico). L'efficienza ipertermica è stata valutata attraverso misure di SAR, a diverse ampiezze e frequenze del campo magnetico alternato. La forma dei profili NMRD, rappresentativa dei meccanismi di rilassamento, risulta dipendere dalla forma e dimensione delle NP, analogamente al rilascio termico.

Plasmonic nanostructures for selective virus detection.
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The study of novel plasmonic nanopatterns are of great interest for different applications including biological investigation and sensing. In this presentation we report some biosensing platforms designed, fabricated and characterized in the frame of the projects "SERSCov-Advanced Nanobiosensing platforms for diagnostics and POC surveillance" funded by POR Campania FESR 2014/2020 (CUP B53C22003100002) and "H2OSafety-Design and development of environmental sensors for the research of microbiological and chemical contaminants hazardous to health" funded by the National Fund Sviluppo e Coesione (FSC) Proof of Concepts projects (POC01_00109). We tested the LSPR and SERS performances analyzing different viruses such as SARS-CoV-2, rotavirus and norovirus. Our results suggest that the considered plasmonic nanopatterns are promising for the development of devices for rapid, label-free and high-sensitivity detection of biological analytes and, moreover, they can be integrated with other on-chip chemical/biological devices to realize portable points-care-tools.

A rate model for evoked and spontaneously replayed oscillations in the rat barrel cortex.
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Rats navigate the environment by using a tactile sense based on vibrissae, in a similar fashion as primates palpate objects with the fingers. This information passes through the thalamus towards the barrel cortex. We investigate the collective oscillations in the barrel cortex of anesthetized rats after whisker stimulation and during spontaneous activity, analyzing cortico-thalamic recordings. In agreement with previous work, we observed that after

stimulation, oscillations at 10–11 Hz appear in the local field potential in several layers of the barrel cortex. They are similar to a spindle oscillation that has been observed both in behaving and anesthetized rats. We then track the oscillation during spontaneous activity, and see that the 10–11 Hz oscillation is replayed by the cortex, nested with a lower delta oscillation. We are able to model these experimental facts with a simple rate model of the barrel cortex created by Pinto and Ermentrout, giving as input the experimental firing rate of the thalamus. The model reproduces the fact that the cortex after whisker stimulation enters into a limit cycle, and reproduces also the spontaneous activity replay of oscillations.

Critical dynamics during human sleep.

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Recent experimental results and theoretical models have supported the idea that brain self-organizes toward a critical point, to maximize dynamical range and computational capabilities. In humans, sleep plays a crucial role to re-tune the system towards criticality. In this talk we explore neural avalanches, and the scaling relationships among critical exponents, in overnight EEG recordings in human healthy subjects, during NREM sleep. Notably, the distributions of the avalanches' size and duration, and mean size as a function of duration, are well described by a power laws with critical exponents in agreement with mean-field directed percolation class. Moreover, we study the correlation between the avalanches' spatiotemporal structure and the sleep macro and microstructure as reflected by the CAP framework. Overall, our findings provide evidence of a link between the avalanche's occurrence, slow-wave sleep dynamics, sleep stages transitions and CAP-phase A.

Predictive model of complete responders to neoadjuvant chemotherapy in breast cancer: validation on an independent set.

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The purpose of this study is the validation of a predictive MRI-based radiomic-histological model of complete response to NeoAdjuvant Chemotherapy (NAC) in breast cancer on an independent dataset. A previously published model was validated on an independent database.

The model is based on clinical and radiological data (grade and margin), histological information (Ki-67, Estrogen Receptor and HER2) and IBSI compliant radiomics features. The validation set includes 66 women (34 complete and 32 non-responders) treated with NAC. Radiomic features were extracted from 3T DCE MRI. The published logistic model was regularised with Elastic Net using $\gamma = 0.04$ and $\alpha = 0.7$ ("glmnet" library of *R*). The final model AUC was evaluated with a Leave One Out Cross Validation (LOOCV) and the AUC was computed (pROC library of *R*). Successively the model was refitted considering the union of validation and training set (126 patients). The AUC obtained is 0.86 [0.76–0.96]. Applying the regularised model to the validation set an AUC of 0.76 [0.64–0.88] was obtained. After refitting the model on complete set AUC was 0.85 [0.78–0.91]. The validation group data led to an AUC of 0.76, showing good prediction ability.

Artificial intelligence algorithms for cancer prediction through breath analysis.

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Our research aims at studying the onset of cancer diseases through the analysis of breath. By determining the abundance of around 250 molecules present in the human breath, obtained through gas chromatography – mass spectrometry, we have studied the cases of patients affected by prostate and breast cancer. After a preliminary selection process of the most important molecules for the discrimination between healthy controls and affected subjects, we have implemented a Random Forest Machine Learning algorithm. Applying the proper statistical tests, consisting in 10-fold cross validation repeated 100 times, we have quantified the performance of the considered machine learning algorithm. The results indicate very good performances both for the healthy/affected discrimination of breast cancer (accuracy 75%, specificity 80%, sensitivity 68%) and for the three considered levels, classified according to PI-RADS values, in the case of prostate cancer (accuracy 71%).

Indice di miocardite definito da un algoritmo di riconoscimento basato sulla PCA applicato all'analisi triassiale di immagini di risonanza magnetica del muscolo cardiaco.

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In questo lavoro viene presentato un indice di miocardite calcolato dall'analisi di immagini di risonanza magnetica del muscolo cardiaco, attraverso un algoritmo di riconoscimento basato su PCA sui domini i cui contorni sono definiti dall'operatore. L'algoritmo, dopo un fase di preprocessing delle slices e dei domini, analizza i volumi per il calcolo dell'indice di miocardite e del relativo intervallo di confidenza. L'algoritmo è stato testato esaminando un gruppo di pazienti con diagnosi clinica di miocardite. Gli indici ottenuti sono stati confrontati con una variabile ordinale che rappresentava la valutazione in cieco della gravità della miocardite data da due radiologi sulla base delle casistiche dei pazienti. I risultati mostrano una correlazione significativa tra gli indici di miocardite e le valutazioni dei radiologi con

buona riproducibilità intra-osservatore e inter-osservatore. L'indice di miocardite proposto non sostituisce la valutazione del radiologo, ma potrebbe essere utilizzato per correlare quantitativamente le valutazioni delle immagini con altri parametri biologici per lo sviluppo di migliori protocolli diagnostici.

Studio dell'esposizione ai campi degli operatori MRI tramite simulazione computazionale.

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Gli operatori MRI sono esposti al campo magnetico statico disperso e uno spettro complesso è generato dal loro movimento in un campo spazialmente variabile. Le esposizioni a campi elettromagnetici sono regolate dalla Direttiva 2013/35/UE che, per spettri complessi prevede l'utilizzo del metodo del picco ponderato (WP) per il calcolo dell'indice di esposizione. Implementando il modello Boulic-Thalmann per la camminata, i movimenti di un operatore nel campo disperso di una sala MRI sono stati simulati per individuare i punti con maggiore indice di esposizione al variare della distanza dal bore, dalla velocità di rotazione e torsione di torace, testa (*shaking, nodding*) e degli arti. Questo approccio, basato su movimenti naturali, permette una stima dell'indice di esposizione di ogni distretto corporale più accurata di quelle esistenti in letteratura. Dalle simulazioni si ottengono indicazioni sui distretti maggiormente suscettibili di superare i limiti di legge e un input per successive simulazioni elettromagnetiche *fullwave* del modello dielettrico del corpo umano che permettono di capire i legami tra la fisiologia e gli effetti sensoriali di cui si lamentano gli operatori MRI.

Ottimizzazione di un fascio neutronico ottenuto con acceleratore RFQ da 5 MeV accoppiato a target di Be per Boron Neutron Capture Therapy.

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La Boron Neutron Capture Therapy (BNCT) sta conoscendo un rapido sviluppo nell'applicazione clinica grazie alla recente disponibilità di fasci di neutroni basati su acceleratori di protoni. L'INFN ha sviluppato un acceleratore RFQ che produce un fascio di protoni da 30 mA e 5 MeV, che accoppiato ad un bersaglio di Be, fornisce un'intensa sorgente di neutroni (10^{14} s^{-1}). Il progetto ANTHEM, finanziato dal PNRR, prevede la costruzione di un centro clinico di BNCT a Caserta basato su questa tecnologia. L'ottimizzazione del fascio per tumori profondi richiede un *Beam Shaping Assembly* (BSA), una struttura composta di diversi materiali e geometrie per modificare lo spettro e la collimazione del fascio che si produce sul target. Un modello di BSA basato sul materiale innovativo AlF_3 densificato è stato progettato, dimostrando che è possibile ottenere un fascio con stesse performance dosimetriche di fasci già utilizzati in clinica. Per la costruzione del centro clinico gli sforzi si stanno concentrando sulla simulazione di una versione più semplice dal punto di vista costruttivo. Vengono presentate simulazioni per il raggiungimento della configurazione ottimale.

Aula F5 - Hildred Blewett **ore 09:00 – 13:30**

Sezione VI
Fisica applicata, acceleratori e beni culturali
Presiede: Latronico L. (INFN, Sezione di Torino)

Relazioni su invito

▲ **Il tokamak DTT: Stato del progetto e la sua collocazione nel contesto internazionale.**
Ciotti M.
ENEA, Divisione fisica dei plasmi
Il progetto DTT viene illustrato e contestualizzato nell'ambito della programmazione prevista da EURO fusion (roadmap) verso la realizzazione di una centrale elettrica a fusione nucleare. Le scelte strategiche operate sono confrontate con le linee di ricerca in essere in ambito internazionale.

▲ **Uso sinergico delle tecniche PIXE-PIGE e di opportuni campionatori per lo studio del particolato atmosferico.**
Giardi F. ([1]), Calzolai G. ([1]), Chiari M. ([1]), Fratticioli C. ([1])([2]), Lucarelli F. ([1])([2]), Nava S. ([1])([2]), Ottanelli P. ([1]), Cialdai C. ([1])
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Presso l'INFN di Firenze, il LABEC (laboratorio di tecniche nucleari per l'ambiente e i beni culturali) ospita un acceleratore Tandetron da 3 MV nel quale da anni è presente un set-up con fascio esterno interamente dedicato a misure PIXE-PIGE della composizione elementale dell'aerosol atmosferico. L'attuale configurazione consente un facile posizionamento automatico, lo spostamento e la scansione in tempi brevi dei campioni di PM_x raccolti da diversi tipi di dispositivi. La PIXE è una tecnica che offre numerosi vantaggi per lo studio di questo tipo di campioni: permette l'analisi multi- elementale (per elementi con $Z > 10$); i tempi di misura sono estremamente brevi se confrontati con altre tecniche analitiche (circa 1 minuto per ogni campione); presenta bassi detection limit che permettono la quantificazione dei maggiori elementi ma anche di metalli in traccia e ultra-traccia; è una tecnica non distruttiva, permettendo l'analisi con tecniche complementari dei campioni già analizzati; non necessita di alcuna preparazione dei campioni, riducendo così le possibili contaminazioni dovute all'uso di reagenti per la solubilizzazione degli elementi. Grazie alla capacità di rilevare tutti gli elementi crostali, le analisi PIXE-PIGE sono molto efficaci nello studio dell'aerosol naturale, come, ad esempio, le intrusioni delle polveri sahariane. Tra gli elementi rilevabili vi sono anche importanti marcatori di sorgenti antropiche che consentono efficaci studi di source apportionment in ambienti urbani mediante l'utilizzo di metodi multivariati come la Positive Matrix Factorization (PMF). L'uso combinato di opportuni campionatori e analisi PIXE permette anche di ottenere la composizione elementale con risoluzione oraria che risulta di fondamentale importanza per la comprensione di processi di emissione o trasporto del particolato. Verrà mostrato quali sono i vantaggi derivanti dall'uso combinato di un adeguato set-up sperimentale di analisi con opportuni campionatori specificatamente progettati per sfruttare al meglio le caratteristiche delle tecniche di Ion Beam Analysis. Per questo verranno presentati anche esempi relativi a campagne di monitoraggio, effettuate in aree urbane e remote, sia su base giornaliera sia con elevata risoluzione temporale (campioni

orari), nonché con selezione dimensionale. Verrà inoltre evidenziata l'importanza dell'uso combinato della tecnica di emissione di raggi gamma indotti da particelle (PIGE) e di altre tecniche complementari (nucleari e non).

Comunicazioni

Preliminary analyses of fuelling systems for DTT.

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DTT is a Tokamak-type experimental device for the study of heat and particle flow in future fusion reactors like DEMO. Even with dimensions ($R/a = 2.10/0.7$ m) much smaller than those of DEMO, in the full power scenario, DTT will be able of producing similar plasma conditions, thanks to its high toroidal magnetic field ($B_t = 6$ T), plasma current (5.5 MA) and 45 MW of additional heating power provided by ECRH, ICRH and a neutral injector. One of the DTT activities concerns the fuel supply system and the mitigation of the disruptions effects by means of gas injection. The study of different injection systems (GIS, SMBI, MGI) is currently underway mainly to understand their characteristics and their adaptability in the DTT context. Three injection techniques are considered: GIS (Gas Injection System) including the system for injecting gas into the experimental device, MGI (Massive Gas Injection) involving the injection of large amounts of different gasses species and SMBI (Supersonic Molecular Beam Injection) based on the injection of a neutral beam of supersonic molecules by using De Laval nozzles. This study is also carried out by considering the experiences on other machines.

Simulations of radio-frequency waves propagation in hot magnetized plasmas.

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We present an analytical modeling and the numerical simulations of radio-frequency waves propagation and absorption in hot magnetized plasmas. The study aims to investigate the thermal effects impact on the waves' dispersion relations through the expansion of the hot plasma dielectric tensor to the first order in temperature, thus including collisionless wave damping mechanisms. The hot tensor is analytically derived and then implemented in the numerical simulations. A comparison between the analytical treatment and the complete expression (obtained numerically) of all the tensor elements is also discussed. We will present an extension of our full-wave cold model based on the interplay between COMSOL and MATLAB that now accounts for a 3D non-homogeneous plasma cold dielectric tensor. As a first step, we will study the wave propagation in a 1-Dimensional (1D) hot plasma. Then,

we will analyze two more complex configurations: the Ion Cyclotron Heating (ICH) on DTT (Divertor Tokamak Test) (2D scenario) and the Electron Cyclotron Heating (ECH) in ECR Ion Sources for particle accelerators (3D scenarios). Both of them will be investigated including the spatial dispersion on the wave vector.

Coupling compact holographic microscopy with deep learning methods for the study of flowing microplastics.

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The issue of plastic pollution in the marine environment is widely recognized as a major ecological hazard, in particular regarding microplastic (MPs). Different procedures have been proposed to detect MPs in liquid samples in flowing conditions by using microfluidics for fluid handling, as it provides the basis for high-throughput and automatic acquisitions. We developed a compact and low-cost holographic microscope, based on common-path off-axis Digital Holography (DH), to observe MP samples dispersed in water and flowing through a commercial microchannel. DH is a non-destructive, single-shot and full-field imaging technique, allowing label-free quantitative phase imaging and flexible *a posteriori* numerical refocusing of flowing samples. The common-path design increases the system stability against vibration, fundamental for further *in situ* analysis. We image and count MPs debris (PP, PS and LPDE) or polymer microfibers shed during the washing of synthetic textiles. Holographic videos provided data on the size, shape, and position of MPs, and in combination with machine and deep learning algorithms allow to identify and classify MPs fibres, separating them from other particles.

Un nuovo gassificatore per biomasse di scarto.

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In Italia ogni anno si raccolgono più di 109 kg di biomasse di scarto. Una delle vie più promettenti per valorizzare a fini energetici tali biomasse, inclusi gli scarti agricoli, è la gassificazione. Il principale prodotto della gassificazione è il syngas, una miscela gassosa ricca di idrogeno e monossido di carbonio, utilizzabile per la produzione di energia tramite motori, turbine e celle a combustibile, o per la sintesi di composti chimici. I gassificatori normalmente lavorano con una quantità ridotta di ossigeno e producono tanto catrame, che finisce con il danneggiare gli impianti. Stiamo invece sviluppando un gassificatore di nuova concezione che lavora in un regime di alto flusso d'aria, riducendo questo problema. Il gas prodotto può poi venire utilizzato come una volta il "gas di città" (con la differenza che il gas prodotto da biomasse è CO_2 neutrale). I primi risultati sono molto incoraggianti: si sta ottimizzando questo apparato e testandolo su diversi tipi di biomassa. Future applicazioni potrebbero includere la produzione di benzina sintetica o la fornitura di idrogeno.

Frequency analysis of resting state muscles hemodynamics to assess endothelial activity.

Amendola C. ([1]), Spinelli L. ([2]), Torricelli A. ([1])([2]), Frabasile L. ([1]), Zanoletti M. ([3]), Cortese L. ([3]), Yaqub M.A. ([3]), Durduran T. ([3])([4]), Mesquida J. ([5]), Contini D. ([1])
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([2]) *Istituto di Fotonica e Nanotecnologie, Consiglio Nazionale delle Ricerche, Milano, Italy*

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([4]) *Institució Catalana de Recerca i Estudis Avançats, ICREA, Barcelona, Spain*
([5]) *Critical Care Department, Parc Taulí Hospital Universitari, Institut D'Investigació i Innovació Parc Taulí I3PT, 1, Sabadell, Spain*
The endothelium is responsible for fundamental processes such as blood vessel tone, and oxygen extraction. Some diseases such as respiratory diseases can affect endothelium functions, causing severe damage to the organisms. Previous studies demonstrated that near-infrared spectroscopy (NIRS) combined with vascular occlusion tests (VOT) allows assessing endothelial activities, and helps discriminate the progression of respiratory disease as acute respiratory distress syndrome. The VASCOVID project (Horizon 2020 European project) aims to evaluate the endothelial health of intensive care unit patients by exploiting VOT combined with new diffuse optical spectroscopies (DOS) technologies: time domain NIRS and diffuse correlation spectroscopy that allow measuring absolute hemoglobin concentration oxygen saturation and blood flow index. In the framework of this project, we studied a new strategy to evaluate endothelial activities by analyzing the frequency response of resting state blood flow. We observed that healthy subjects show peaks in the power spectral density at very low frequencies associated with endothelium functions, demonstrating the great potential of DOS frequency analysis.

Development of monolithic perovskite/silicon tandem solar cells.
Mercaldo L.V. ([1]), Bobeico E. ([1]), De Maria A. ([1]), Della Noce M. ([1]), Ferrara M. ([1]), La Ferrara V. ([1]), Lancellotti L. ([1]), Rametta G. ([1]), Sannino G.V. ([1])([2]), Usatii I. ([1]), Delli Veneri P. ([1]), Di Giacomo F. ([3]), Pourmotlagh S.M. ([3]), Reddy S.H. ([3]), Di Carlo A. ([3])([4])
([1]) *ENEA, Portici Research Center, Portici, Italy*
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([3]) *University of Rome Tor Vergata, Rome, Italy*
([4]) *ISM-CNR, Rome, Italy*
Tandem solar cells combining metal halide perovskite (pk) and silicon subcells have strong potential for high efficiency and low-cost photovoltaics. We report on monolithic pk/silicon-heterojunction (SHJ) tandem solar cells with different architectures, including the case of bottom cell based on p-type Si wafer, main wafer in solar cell production industry. The interconnection region was investigated, considering a tunnel junction based on nanocrystalline Si or a transparent conducting oxide recombination layer. Solution-processed organic-inorganic triple-cation pk solar cells were applied as top component with p-i-n or n-i-p design. For p-type SHJs, n-type nanocrystalline SiO_x was applied as electron selective contact at the flat front side of one-side polished (p) Si wafers. ITO was used as recombination layer followed by the p-i-n pk top cell. Inks based on metal oxide nanoparticles were tested to provide a buffer against the sputter damage induced by the top ITO electrode deposition. The resulting monolithic tandem devices displayed a maximum efficiency of 23.3%. Work is in progress to replace spin-coated with thermally evaporated pk films, also applicable to textured SHJs.

Enhancement of the radon activity concentration in Crotone indoor environments due to the employment of TENORM as inert material
Nicolino A. ([1]), Ligato M.R. ([2]), Ferraro M. ([1])([3]), De Luca F. ([2]), Procopio S. ([4])
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Sapienza University of Rome, Rome, Italy
([4]) *ARPACAL, Ettore Majorana Physics Laboratory-Department of Catanzaro, Catanzaro, Italy*
The Rn-222 in indoor environments may be due to several factors: exhalation from the ground, the soil, building materials and NORM. The processing of NORM may result in the production of TENORM. In this framework, remarkable is the case of Crotone where several chemical factories were specialized in the treatment of phosphorite rocks, rich of U-238 and Th-232. Because of their mechanical properties, in the recent past, the TENORM residues have been employed in the construction of roads, dwellings, warehouses, and public buildings. We propose a down-scaled model of a house, whose crawlspace is filled with TENORM harvested in Crotone. We monitored the indoor environmental radioactivity by using both active and passive device and observed an important increase of the Rn-222 activity concentration, whenever TENORM residues are inserted. Finally, the results of the model were compared to a real use case, a warehouse in Crotone. A good agreement was found between the results of the environmental screening of the warehouse and the predictions of the model in terms of Rn-222 activity. This indicates that Rn-222 can actually be used as a TENORM precursor in order to map the phosphorite contamination.

Study and characterization of zeolites for the removal of artificial radionuclides in wastewater samples from the former Garigliano Nuclear Power Plant in Italy.
Ambrosino F. ([1]), Pisciotta F. ([2]), Esposito S. ([2]), La Verde G. ([1]), Esposito A.M. ([3]), Gravino C. ([4]), Caputo D. ([4]), Pugliese M. ([1])
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([4]) *Department of Materials and Production Engineering, University of Naples Federico II, Naples, Italy*
As one of the most important adsorbents, zeolite can be used as removal of artificial radionuclides from nuclear wastewater of the former nuclear power plant of Garigliano, Italy. The wastewater consists of liquid supernatant of residuals from the operation of the plant. Samples of the wastewater are characterized radiologically by performing γ-spectrometry using HpGe detector: Cs^{137} and Co^{60} are main sources. Zeolites are microporous material with structures containing molecular channels and cages accessible by other molecules by ion exchange. Perusing the literature, the features of zeolites are investigated by examining the percentage removal of radionuclides found: the type A is expected to be the best solution for Cs^{137} and Co^{60}. This work falls within the decommissioning of the facility, by proposing an alternative new solution for correctly managing the problem of radioactive wastewater. The future step is to set up in-batch and in-column pipes experiments where the contaminated liquid passes through, to remove the radionuclides. This step is performed, firstly, by using non-radioactive isotopes of the same nuclides found in wastewater, by studing the exchange isotherm curves.

"Bubble sensor" as an innovative sensor to assess temperature changes.
Panebianco S. ([1]), Galvagno R. ([2]), Trigona C. ([1]), Gueli A.M. ([2])
([1]) *Dipartimento di Ingegneria Elettrica Elettronica e Informatica, Università degli Studi di Catania, Italia*
([2]) *Dipartimento di Fisica e Astronomia "Ettore Majorana", Università degli Studi di Catania, Italia*
Temperature is one of the most monitored parameters for different applications above all in industry through wireless sensors, but the employment of these systems has some limitations

such as the fact that they need to be power supplied. The aim of this study is to implement an innovative and low-cost temperature sensor using Crystal Ball® colourful paste painted with thermochromic varnishes. The characteristic of these paints is that the colour changes as the temperature increases relative to a peak, approximately 35 °C, of the environment. In order to quantify the optical behaviour variations with temperature values, colour measurements by spectroradiometer methodology are performed. The balls have been exposed to different temperatures, ranging from 25 °C to 55 °C in 10 °C steps, inside an oven. For this study crystal balls of blue, red, yellow, and green hues are obtained, while the thermochromic paints used for coatings are blue and red. The results show the potentiality of Crystal Ball® as sensor and allow us to characterise its performance. In particular the chroma C^* values follow a linear behaviour with respect to temperature.

Indium tin oxide/metal nanoparticles composite for H_2 gas detection.

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Hydrogen is a promising substitute to fossil fuels to reduce greenhouse gas emissions. Despite its ecological benefits, H_2 poses safety concerns due to its odorless, colorless, and explosive nature in dilutions in air from 4% to 75% vol., hence, H_2 leak detection is critical during storage and transport. Traditional metal oxide (MOX)-based sensors have limits such as low sensitivity and high working temperatures. As stated in the literature, a way to lessen these limits is to functionalize MOX with metal catalysts, so improving the sensor's performance but mostly using costly synthesis techniques like physical or chemical vapor deposition and sputtering. Our lab has been widely involved in identifying and improving the performance of nanostructured sensing films, aiming at the use of cheap materials, produced with ecofriendly techniques, and at the manufacture of low-energy consumption devices. As a contribution in this area, we present H_2-sensitive composites, made by a simple mixture of commercial ITO functionalized with Rh, Pd, and Pt nanoparticles and able to detect H_2 diluted in 0.5% synthetic air at different working temperatures. This work was funded by MiTE within the PNRR.

TiO_2 nanostructured array for optical ultrasensitive biosensing.

D'Arco A. ([1]), Mancini T. ([2]), Macis S. ([2]), Mosetti R. ([2]), Della Ventura G. ([3]), Marcelli A. ([4]), Paolocci C. ([5]), Chronopoulou L. ([5]), Galstyan V. ([6])([7]), Lupi S. ([1])([2])

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([7]) *Department of Engineering, University of Modena and Reggio Emilia, Italy*

Portable and real-time devices for biosensing are finding various application fields, including air quality for guaranteeing the occupational health, safety and security. Motivated by the request to monitor the airborne pathogens, we illustrate the steps towards the development of infrared TiO_2 nanostructured array. Herein, we fabricated TiO_2 nanotubes (NTs) by means of electrochemical anodization and investigated the prepared samples as the platform for label-free optical monitoring of biomolecules, such as SARS-CoV-2 spike glycoproteins.

In order to increase the NTs sensor selectivity, we chemically modified the surface of TiO_2 NTs to bind the spike glycoprotein. The process of biofunctionalization was monitored and validated by using optical methods, including Infrared spectroscopy. Our results show that the TiO_2 NTs array can be applied as versatile platform for sensing of biochemical molecules interrogable with optical methods.

Stability of a phthalocyanine pigment in the presence of reactive inorganic components.

De Carlo A.

Università degli Studi Roma Tre, Dipartimento di Scienze, Rome, Italia e Institut national de la recherche scientifique, Centre Énergie Matériaux Télécommunications, INRS-EMT, Varennes, QC, Canada

The study of the aging and degradation processes of the materials used by artists is essential in the science applied to the cultural heritage field. Although there are many studies on the aging of pigments, the stability to light of pure pigments or of pigments in interaction with inorganic components is not well known. The aim is to study how highly reactive inorganic components can influence the stability of the phthalocyanine pigments. I am investigating all the possible changes induced by accelerated aging treatments, as a result of exposure under controlled conditions of radiation, temperature and relative humidity, with different analytical techniques: colorimetry, Fourier-transformed infrared and Raman spectroscopy. From the first results, no variations were observed for the pure powders of phthalocyanine and white pigments, demonstrating the strong stability of these molecules. However, a larger color change is observed when the phthalocyanine is mixed with white inorganic pigments. We are now trying to understand how this color variation is linked to possible chemical or physical variations of the organic and inorganic molecules involved, by the spectroscopic techniques.

Aula F2 - Ginestra Giovene Amaldi **ore 09:00 – 13:30**

Sezione VII
Didattica e storia della fisica
Presiede: Giannetto E. (Università di Bergamo)

Relazioni su invito

▲ **On the Greek filiation of Hamilton.**
Amabile A.
Università di Napoli "Federico II", Napoli, Italia
Often regarded as a mile-stone in the history of algebra, Hamilton's quaternions are rarely remembered in their geometrical character. The unfortunate fate of this theory has obscured its original meaning, and in this communication we will try to restore it by appealing to its creator's own words. In particular, we will argue that quaternions were, in Hamilton's own view, the realization of the Pythagorean conception of mathematics as the science of order rather than of quantity.

▲ **Il pendolo di Focault e quello di Viviani.**
Mazzoni M., Bagnoli F., Livi R.
Università di Firenze, Firenze, Italia
Il pendolo di Foucault è considerato uno dei più bei esperimenti scientifici perché permette di visualizzare direttamente il moto rotatorio della Terra. Ma questo è proprio l'argomento della seconda giornata del Dialogo di Galileo, che usa l'argomento (errato) delle maree. È quindi sorprendente trovare l'effetto descritto dagli Accademici del Cimento in più occasioni. Ma è possibile visualizzare la rotazione della Terra con un pendolo lungo circa 1,5 m (come quello usato all'Accademia del Cimento) senza un meccanismo di alimentazione? La risposta ce la fornisce lo stesso Foucault, che riporta che nel suo primo esperimento, fatto con un pendolo lungo 2 m, l'effetto è già visibile nel giro di un minuto. Abbiamo confermato le osservazioni usando una replica del pendolo di Viviani e altri pendoli, usando una punta per tracciare la deviazione su della cenere. Perchè gli accademici non hanno sfruttato l'effetto per dimostrare la rotazione della Terra e anzi, *e anzi finiscono con l'appender la palla a un fil doppio*? Probabilmente perché Galileo stesso considerava il moto circolare come "naturale", e quindi che non fossero necessarie forze aggiuntive per mantenerlo.

▲ **Instrument makers serving science: the Italian network in the 19th century.**
Mantovani R.
Dipartimento di Scienze Pure e Applicate, "Gabinetto di Fisica: Museo urbinate della Scienza e della Tecnica", Università di Urbino Carlo Bo, Urbino, Italia
In the 19th century, instrument makers played a crucial role in physical sciences research and teaching growth. In Italy, especially in the first half of the nineteenth century, the professional figure of the machinist was consolidated within universities, observatories, schools and other scientific institutions. The latter was a highly skilled mechanic with the skills to build scientific instruments, repair, modify, and keep them in good working order and preservation. Especially in northern Italy, some machinists, setting up their own businesses, began to market a variety of scientific instruments, often advertising them through trade catalogues. These activities, generally confined to local or regional areas, stimulated the emergence of an Italian precision scientific equipment industry after the unification of Italy. Some

of these industries, such as the "Tecnomasio Italiano", the "Officina filotecnica" and the "Officine Galileo", succeeded in establishing the country thanks to good scientific production. However, they could not adequately counter, in quantity and quality, the much more efficient and organized foreign production, especially that of Germany, starting around 1870.

▲ Le nove scoperte planetarie di Annibale de Gasparis: dalla celebrità scientifica alla notorietà popolare.

Gargano M.
INAF-Osservatorio Astronomico di Capodimonte, Napoli, Italia

Annibale de Gasparis (1819-1892) è stato matematico e astronomo, direttore dell'Osservatorio di Capodimonte e senatore del Regno d'Italia, famoso soprattutto per la scoperta di 9 asteroidi, il maggior numero di scoperte effettuate in Italia nel corso del XIX secolo. Dalla ricostruzione della sua corrispondenza, fatta di oltre 500 lettere scambiate con oltre 120 corrispondenti, tra cui Herschel, Le Verrier, Arago, Secchi e Sella, emerge il rilevante ruolo di De Gasparis per gli sviluppi matematici della meccanica celeste, come testimoniano le affermazioni di Cauchy e di Hermite. Inoltre, la sua reputazione scientifica ha travalicato i confini dell'astronomia, divenendo celebre sui giornali e sulle riviste dell'epoca che resero popolare il valore scientifico delle sue scoperte. Lo studio delle lettere e degli articoli giornalistici offre una visione chiara delle relazioni e degli interessi scientifici di de Gasparis e presentano uno spaccato della bonarietà umana dell'astronomo.

▲ Intrecci di conoscenze storico-astronomiche sulla Luna di Giambattista Riccioli.

Zanini V.
INAF-Osservatorio Astronomico di Padova, Padova, Italia

La selenografia presentata da Giambattista Riccioli (1598-1671) nel suo *Almagestum novum*, a metà del XVII secolo, divenne nel tempo il riferimento della nomenclatura lunare. Il criterio di associare i nomi di celebri astronomi antichi e moderni alle varie macchie lunari fu scelto infatti anche dall'Unione Astronomica Internazionale, nel 1932, come base di una toponomastica lunare condivisa a livello internazionale. La mappa lunare del Riccioli, inoltre, è ancora oggi importante perché i nomi in essa contenuti ci danno indicazioni rispetto ai protagonisti della scienza astronomica nel Seicento. Il Riccioli, infatti, collocò sulla superficie lunare solo studiosi di astronomia o di astrologia genetliaca che avessero offerto un efficace contributo all'avanzamento delle conoscenze astronomiche, il lavoro dei quali fu da egli stesso utilizzato per redigere il suo *Almagestum*. Gli scienziati da lui collocati sulla Luna appartengono a tutte le epoche della storia umana, quindi ci raccontano sia quale fosse la cultura storico-astronomica del Seicento, sia qual era la rete di rapporti scientifici che Riccioli aveva intessuto con i suoi contemporanei.

▲ La progettazione di sequenze di insegnamento-apprendimento basate sugli esperimenti.

Onorato P.
Dipartimento di Fisica, Università di Trento, Povo, TN, Italia

La progettazione, la realizzazione e la valutazione di sequenze d'insegnamento-apprendimento (Teaching learning sequences, TLS) costituiscono uno dei temi fondamentali della ricerca in didattica della fisica. In questa comunicazione introdurremo brevemente alcuni dei più rilevanti quadri teorici che guidano la scelta dei contenuti e delle risorse di apprendimento, lo sviluppo, la valutazione e la riprogettazione di una TLS. Quindi saranno discusse alcune sequenze, sperimentate nell'ultimo decennio e fortemente fondate sugli esperimenti. Infatti, la costruzione di concetti attraverso attività sperimentali permette da un lato di coinvolgere

maggiormente gli studenti, dall'altro di raggiungere gli obiettivi di apprendimento per il laboratorio di fisica indicati dalle recenti ricerche internazionali. Si mostrerà come si possano alternare e integrare sinergicamente esperimenti qualitativi e quantitativi, con simulazioni e generalizzazioni teoriche.

Comunicazioni

Look up! Sfoglia il cielo con un dito - Una mostra virtuale per valorizzare gli atlanti astronomici storici dell'Istituto Nazionale di Astrofisica.

Di Giacomo F. ([1]), Faccini M. ([2]), Gargano M. ([3]), Gasperini A. ([4]), Zanini V. ([1])
([1]) *INAF - Osservatorio Astronomico di Padova, Padova, Italia*
([2]) *INAF - Osservatorio Astronomico di Roma, Roma, Italia*
([3]) *INAF - Osservatorio Astronomico di Capodimonte, Napoli, Italia*
([4]) *INAF - Osservatorio Astrofisico di Arcetri, Firenze, Italia*

Le nuove tecnologie stanno influenzando ogni aspetto della nostra vita. Allo stesso modo l'utilizzo di strumenti digitali sta diventando sempre più importante anche nell'ambito della tutela, conservazione e valorizzazione del patrimonio culturale. In questo contesto è stata realizzata la mostra virtuale "Look up! Sfoglia il cielo con un dito". Si tratta di un efficace strumento digitale volto a preservare, valorizzare e dare massima diffusione a una selezione della collezione di atlanti celesti, cometografie e selenografie conservati negli Osservatori INAF. Tali opere rappresentano testimonianze di rara bellezza che fondono arte, mitologia e scienza, oltre ad avere un ruolo di particolare importanza nella storia della cultura scientifica. Grazie alla VR, modelli 3D, video e audio, i visitatori possono esplorare il contenuto scientifico e culturale degli atlanti, interagendo con essi per avere informazioni sulla cosmologia del tempo. Utilizzando i contenuti della mostra sono stati realizzati, con Save the Children, sei attività didattiche che sfruttano il patrimonio culturale dell'astrofisica italiana come strumento di crescita e occasione per sviluppare nuove competenze e passioni.

A cavallo di un fotone: an educational escape room to discover the journey of light in the Solar System.

Mignone C., Sandri M., Galleti S., Leonardi L., Di Giacomo F., Fulco M. T.
INAF - Istituto Nazionale di Astrofisica

This communication presents "A cavallo di un fotone" (in English: "On board a photon"), an educational escape room designed by INAF, the Italian National Institute for Astrophysics. The experience, aimed at secondary school students (aged 11-18), combines coding and robotics in a playful way with a scientific narrative "the journey of light in the Solar System" to discover new topics in physics and astronomy while practicing computational thinking. Each challenge is centred on a key step in a photon's journey towards an astronomical image. Players start as photons at the centre of the Sun, replicating with the help of small robots the long path of light particles in the solar interior. Then, they must decode clues from crypted devices and unplugged coding exercises to figure out towards which planet their photon is directed. Once reflected at the planet, they have to reveal the photon's final destination "a telescope on Earth" and reach it using another robot. We shall present the design and implementation of the escape room, how to replicate it in other contexts, as well as findings from a student evaluation conducted at the Genova science festival, where it premiered in 2022.

La piattaforma di didattica innovativa Play INAF.

Sandri M., Bandiera R., Casu S., Contino G., Daricello L., D'Alessio F., Di Giacomo F., Falco M., Fulco M. T., Galleti S., Giobbi G., Inchingolo G., La Parola

V., Leonardi L., Leoni R., Malaspina M., Mignone C., Olmi B., Pastore S., Ricciardi S., Rifatto A., Sandrelli S., Toniolo R., Trinchieri G., Varano S., Villa F., Zanazzi A., Zanella A.
INAF, Italia
Play INAF è la piattaforma multilingue di didattica innovativa dell'Istituto Nazionale di Astrofisica play.inaf.it che quest'anno ha ricevuto il premio CLASSified Award 2023 come uno dei 100 migliori prodotti del 2022 nel settore dell'innovazione tecnologica e digitale. Il filo conduttore di tutte le risorse proposte sulla piattaforma è la didattica dell'astronomia e della fisica, attraverso attività che sviluppano il pensiero computazionale, le abilità di problem solving e le competenze digitali. Otto sono le categorie alle quali appartengono le risorse presentate sulla piattaforma: coding, robotica educativa, making, tinkering, laboratori hands-on, realtà virtuale, realtà aumentata e giochi. Tutte le risorse sono originali, gratuite, liberamente accessibili, disponibili in più lingue (italiano, inglese, francese e tedesco) e sono rivolte a famiglie, studenti e insegnanti. Da quando è stata pubblicata, nel settembre del 2020, la piattaforma conta oltre 55mila utenti. Negli ultimi 12 mesi i nuovi utenti sono stati 29mila, distribuiti in tutto il mondo, a testimonianza del fatto che Play INAF è, di fatto, una piattaforma internazionale, al servizio della comunità.

Galileo's physics in high school teaching within the framework of the nature of science: a comprehensive educational experimentation.

Cioci V. ([1])([2])
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This work is the result of 6 years of historical research and educational experimentation while I was a PhD student at the University of Lille (France) under the supervision of Professor Raffaele Pisano. Galileo's original texts and manuscripts concerning falling motion and parabolic motion were analysed, as well as the works of his precursors, in order to design a theoretical and laboratory educational path aimed at overcoming the main misconceptions and learning difficulties experienced by students. The rigorous analysis of the educational experimentation showed that students had changed their interest in physics, considered as an experimental science, and in the context in which physics historically developed. An important aspect, however, has been successfully reproduced with the students, in laboratories and school classrooms, the famous experiments performed by Galileo that sanctioned the birth of the experimental method. See: Cioci V.: *Galileo's Falling Bodies into the History of Physics and the Nature of Science as a Case Study*, Doctoral Thesis under the supervision of Pisano R., University of Lille. Theses.fr/2022ULILH052 (2022).

Incontri di Fisica: il corso di formazione per docenti ai Laboratori Nazionali di Frascati dell'INFN.

Postiglione A., Bertelli S., Arnone S., Bifaretti D., Patrignanelli E., Reda S., Santinelli E.
INFN, Laboratori Nazionali di Frascati, Frascati, RM, Italia
Negli ultimi anni sempre più sforzi si concentrano sulla necessità di introdurre la fisica moderna in modo significativo nelle scuole secondarie di II grado, così da fornire a studenti e studentesse gli strumenti per avere una visione della fisica più realistica e aggiornata. In questo contesto, le Università e gli Enti di Ricerca possono giocare un ruolo fondamentale nelle iniziative di formazione docenti, poiché possono creare uno spazio aperto e fertile di condivisione e discussione tra il mondo della scuola e quello della ricerca. I Laboratori Nazionali di Frascati (LNF) dell'Istituto Nazionale di Fisica Nucleare (INFN), in particolare, sono impegnati da più di vent'anni in attività di formazione docenti provenienti da tutt'Italia. In

questo contributo presenteremo nello specifico l'esperienza raccolta nelle ultime edizioni del corso "Incontri di Fisica", che, partendo da un tipo di formazione costituita principalmente da lezioni teoriche di tipo trasmissivo, è oggi diventato un buon esempio di condivisione della pratica laboratoriale sulla fisica moderna.

Aula P1 **ore 14:30 – 15:10**

Sezione III
Astrofisica
Presiede: Capaccioli M. (Università di Napoli Federico II e INAF)

Relazione Generale

Il futuro dell'osservazione del cielo.
Zerbi F.M.
INAF, Roma
Per comprendere l'universo e i meccanismi che lo governano non possiamo che muovere dalle osservazioni, ovvero dalla raccolta del massimo numero di messaggeri (fotoni, neutrini, onde gravitazionali) e dalla determinazione sempre più dettagliata dalle loro caratteristiche (energia, direzione di provenienza). Nei quattrocento anni dalla scoperta dei satelliti di Giove da parte di Galileo la tecnologia ha esercitato un ruolo centrale nell'affinare la capacità dell'uomo di osservare e comprendere l'Universo. Telescopi sempre più grandi e con strumentazione sempre più raffinata hanno consentito progressi inauditi nella conoscenza. Nel corso delle ultime decadi l'avvento della Radioastronomia e del volo spaziale, con la possibilitàdi porre rivelatori per alte energie fuori dall'atmosfera che le scherma, ha allargato lo spettro delle osservabili dando origine alla astrofisica multifrequenza. Recentissimamente il progresso nella rivelazione dei neutrini di origine cosmica e delle onde gravitazionali ha evoluto l'astrofisica multifrequenza nell'astrofisica multi-messaggero promettendo per le prossime decadi ulteriori scoperte di grande interesse. In questo contributo passeremo in rassegna le maggiori infrastrutture per la ricerca astrofisica da terra e da spazio, correntemente in esercizio o in costruzione. Discuteremo del razionale scientifico per la loro costruzione e della scienza che verrà presumibilmente resa possibile dal loro uso e dalle loro sinergie.

Aula P1 **ore 15:10 – 15:50**

Sezione V
Biofisica e fisica medica
Presiede: Bisogni M.G. (Università di Pisa)

Relazione Generale

Le frontiere della ricerca della fisica applicata alle scienze della vita.
Cuttone G.
INFN, Laboratori Nazionali del Sud, Catania
Nel campo della ricerca applicata alle scienze della vita si stanno aprendo nuovi scenari che danno alla fisica un ruolo ancora più ampio e significativo. In particolare lo sviluppo dei laser ad alta potenza offre nuove e stimolanti frontiere nel campo della accelerazione di particelle cariche fino ad energie e ratei di dose che aprono innovativi scenari nel campo dei trattamenti radianti in modalità "flash therapy". Nuove infrastrutture di ricerca stanno nascendo nel nostro paese che si affiancano a quelle già in avanzata fase di realizzazione in Europa. Parimenti lo sviluppo delle tecniche di intelligenza artificiale e di deep learning applicate a grandi moli di dati, tipiche degli esperimenti di fisica particellare, astroparticellare e nucleare, fa sì che trovino sempre più ampie prospettive di applicazione nella ricerca nel campo delle scienze della vita. Anche in questo ambito si stanno realizzando nuove infrastrutture tecnologiche e di ricerca che pongono il nostro paese in una posizione di leadership al livello internazionale. Questi nuovi scenari di sviluppo e ricerca scientifica e tecnologica saranno ampiamente presentati delineando il ruolo fondamentale che enti di ricerca e università stanno avendo anche grazie alle opportunità offerte dal Programma Nazionale di Ripresa e Resilienza (PNNR) che l'Italia porta avanti nell'ambito del programma europeo "Next Generation EU".

Aula P1 **ore 15:50 – 16:30**

Sezione VII
Didattica e storia della fisica
Presiede: Esposito S. (INFN e Università di Napoli Federico II)

Relazione Generale

Fisici italiani e cooperazione internazionale: La nascita delle organizzazioni IUPAP e EPS e il loro ruolo nella storia.
Lalli R.
Politecnico di Torino e Max Planck Institute for the History of Science
Negli ultimi anni il ruolo della cooperazione scientifica internazionale nelle relazioni tra popoli e nazioni è emerso come tema centrale di discussione in ambienti accademici e politici. Scienziati, politologi e politici si interrogano sulle relazioni tra scienza e diplomazia cercando di ideare modalità che possano rendere le azioni di diplomazia scientifica più efficaci, specialmente per affrontare sfide di carattere globale. La mia relazione affronta questo tema discutendo le connessioni tra fisica e politica nella nascita e sviluppo di due istituzioni sorte con l'obiettivo di coordinare diverse comunità internazionali di fisica: la International Union of Pure and Applied Physics, fondata nel 1922 all'interno dell'International Research Council, e la European Physical Society, stabilita nel 1968 come società di riferimento dei fisici in Europa. Partendo da ricerche recenti sulla storia di queste istituzioni, la relazione si focalizza sul ruolo dei fisici italiani in tali istituzioni e sul significato che queste assunsero per la fisica e la politica scientifica italiana in diversi contesti storici durante il XX secolo. Si mostrerà, innanzitutto, che i fisici italiani ebbero un ruolo centrale in diversi momenti cruciali nella storia della IUPAP e della EPS, e, in secondo luogo, si individueranno alcune delle ragioni principali alla base di tale impegno.

Aula P1 **ore 16:30 – 18:00**

Assemblea Generale dei Soci

L'Assemblea Generale dei Soci della Società Italiana di Fisica è convocata in occasione del Congresso Nazionale SIF 2023 in prima convocazione alle ore 16.00 e in seconda convocazione alle ore 16.30 di martedì 12 settembre 2023, l'Assemblea si riunirà nell'aula P1 del Dipartimento di Fisica dell'Università di Salerno con il seguente ordine del giorno:

1) Approvazione dell'ordine del giorno.
2) Approvazione del verbale dell'Assemblea Generale dei Soci del 13 settembre 2022.
3) Relazione del Presidente.
4) Relazioni del Collegio dei Revisori dei Conti e approvazione dei bilanci consuntivi 2022.
5) Ratifica e nomina dei Revisori dei Conti.
6) Discussione e approvazione della Relazione del Presidente.
7) L'editoria della SIF: passato, presente e futuro al servizio della fisica.
   Intervento di B. Ancarani
8) Varie ed eventuali.

Il Presidente della SIF
Angela Bracco

Aula P1 **ore 18:00 – 19:00**

Evento dedicato alle celebrazioni del 25° anniversario della rivista The European Physics Journal (EPJ)

Aula F1 - Augusta Manfredini **ore 09:00 – 13:30**

Sezione I
Fisica nucleare e subnucleare
Presiedono: Imbriani G. (INFN, Sezione di Napoli)
Cuttone G. (INFN, Laboratori Nazionali del Sud)

Relazioni su invito

▲ **Nuclear physics in underground laboratories: Results and future perspectives of the LUNA experiment.**
Ciani G.F. per la LUNA Collaboration
Università degli Studi di Bari e INFN, Sezione di Bari
In order to improve the knowledge about the mechanism of energy production and for the nucleosynthesis of elements in stars or during the Big Bang nucleosynthesis, it is crucial to measure cross-sections of the relevant nuclear reactions with uncertainties below 10%. In stellar environment, nuclear reactions occur at energies far below the Coulomb barrier, their cross-sections are often too small and signals would be overwhelmed by cosmic-ray–induced background. To overcome this limit, several complementary techniques have been used in the last decades, such as recoil separator or indirect methods (THM, ANC). More than 30 years ago, LUNA (Laboratory for Underground Nuclear Astrophysics), installed at the Gran Sasso National Laboratories (Italy), pioneered underground nuclear astrophysics. Thanks to the natural shielding of 1300 m of rock, muonic and neutron backgrounds are reduced by six and three orders of magnitude, respectively, achieving the so-called cosmic silence, suitable for the study of rare events. In this communication, I will give an update on the latest results and future perspectives of the LUNA experiment.

▲ **Programs on radioisotopes for nuclear medicine at LNL and international connections: The LARAMED and ISOLPHARM projects.**
Cisternino S., Ballan M.
Istituo Nazionale di Fisica Nucleare, Laboratori Nazionali di Legnaro, Italia
Radiopharmaceuticals are important tools for the modern nuclear medicine routines and the production of innovative and alternative radionuclides of medical interest is fundamental for the research advancement in the field. In such framework, at INFN-LNL, two complementary multidisciplinary accelerator-based projects, LARAMED (LAboratory of RAdionuclides for MEDicine) and ISOLPHARM (ISOL technique for radioPHARMaceuticals) will exploit the 70 MeV proton cyclotron of the SPES (Selective Production of Exotic Species) facility for the production of medical radionuclides. In particular, LARAMED is focused on the direct-activation method exploring the proton-based production of Tc-99m, Cu-67, Mn-52, Sc-47 and recently Tb-isotopes. ISOLPHARM will study innovative radionuclides such as Ag-111 using the SPES ISOL (Isotope Separation On-Line) facility. The combination of the electromagnetic mass separation, typical of the ISOL technique, and an eventual chemical separation process will ensure a high specific activity final product. The current research activities, with a focus on the selection of the optimal production routes and developed technologies, will be presented in detail.

▲ **Verso la clinica della terapia per cattura neutronica sul boro 10.**
Postuma I.
INFN, Sezione di Pavia, Pavia, Italia
La terapia per cattura neutronica sul boro (BNCT) è una tecnica di radioterapia che sfrutta il rilascio di particelle ad alto LET dalla reazione tra neutroni termici e boro 10. La tecnica prevede la somministrazione di un composto contenente boro 10 al paziente, il quale si accumula nel tessuto tumorale con concentrazioni maggiori rispetto ai tessuti sani. Successivamente, il paziente viene irraggiato con un fascio di neutroni epitermici (0.5 eV $< E <$ 1 keV) che genera un campo di neutroni termici nel volume tumorale. La fisica gioca un ruolo fondamentale nella BNCT, poiché la terapia richiede la generazione di fasci di neutroni e la loro guida verso il tumore attraverso l'uso di dispositivi di moderazione, collimazione e filtraggio. Inoltre, la distribuzione di dose all'interno del tumore e dei tessuti sani circostanti dipende dalle proprietà fisiche del fascio di neutroni, nonché dalle proprietà di assorbimento e diffusione del boro all'interno delle cellule tumorali. Nell'ambito del progetto Anthem finanziato dal PNRR integreremo tutti i progressi tecnologici per realizzare un centro clinico BNCT a Caserta. Si mostreranno le sfide connesse al raggiungimento di questo obiettivo.

▲ **Study of hadron beam fragmentation with the FOOT experiment.**
Galati G. per la FOOT Collaboration
Università di Bari "Aldo Moro" e INFN, Sezione di Bari
Particle therapy uses protons and heavy ions for the treatment of deep-seated solid tumours, but the biological damage due to beam-induced tissue fragmentation is still an open issue: effects linked to target fragmentation are hard to evaluate and neglected in clinical practice. The FOOT experiment measures nuclear fragmentation cross-sections in the 50–800 MeV/A beam energy range with about 5% uncertainty. Target nuclei (^{16}O, ^{12}C) fragmentation induced by proton beams is studied via an inverse kinematic approach employing ^{16}O and ^{12}C beams impinging on graphite and polyethylene targets. Two complementary setups are used: the "emulsion configuration" measures the production of light charged nuclear fragments ($Z \leq 3$), while the "electronic configuration" focuses on the heavier ($Z \geq 3$) fragments. This communication will discuss the goals and status of the FOOT experiment, as well as the first cross-section fragmentation results obtained by the two experimental setups with 200 MeV/A and 400 MeV/A ^{16}O beam on C, C_2H_4 and H. Accurate data on fragmentation cross-sections can be used to improve the current Relative Biological Efficiency models and the clinical treatment plans.

Comunicazioni

● **^{17}O destruction rate in stars.**
Rapagnani D. ([1]), Straniero O. ([2])([3]), Imbriani G. ([1]), Best A. ([1]), Di Leva A. ([1])
([1]) *Dipartimento di Fisica "E. Pancini", Università degli Studi di Napoli "Federico II" e INFN, Sezione di Napoli*
([2]) *INAF-Osservatorio Astronomico d'Abruzzo, Teramo*
([3]) *INFN, Sezione di Roma*
When stars approach the red giant branch, a deep convective envelope develops and the products of the CNO cycle appear at the stellar surface. In particular, the ^{17}O is enhanced in RGB and AGB stars. Then, spectroscopic analyses of O isotopic ratios of these stars provide a powerful tool to investigate the efficiency of deep mixing processes, such as those powered by convective overshoot, rotation, thermohaline instability, gravity wave and magnetic field. However, this method requires a precise knowledge of the reaction rates that determine the ^{17}O abundance in a H-burning shell, among which the ^{17}O(p, γ)^{18}F and the ^{17}O(p, α)^{14}N

reactions are the more relevant. Since the last release of rates compilations (see the JINA reaclib database) a number of experiments have updated the reaction rates, incorporating new low-energy cross-section measurements. To provide up-to-date input to the astrophysics community, we performed simultaneous multi-channel and Monte Carlo R-matrix analyses of the two reactions including all newly available data, resulting in realistic uncertainty ranges for the rates.

The ^{14}N(p, γ)^{15}O reaction measurement in the framework of the LUNA-MV project.

Compagnucci A. per la LUNA Collaboration
Gran Sasso Science Institute

The ^{14}N(p, γ)^{15}O is the slowest reaction of the CNO cycle and therefore controls the speed of this process, directly influencing the predicted CNO solar neutrino rates and the lifetime of massive stars. This reaction has been already extensively studied over the years by LUNA (Laboratory for Underground Nuclear Astrophysics) and other groups down to 70 keV. Nonetheless, a renewed measurement over an extensive energy range is still needed to solve the inconsistencies that remain between low-energy measurements and extrapolation from higher-energy data. The LUNA Collaboration will measure ^{14}N(p, γ)^{15}O excitation function and angular distribution with high-purity germanium detectors as a pilot project of the LUNA-MV program. This will be possible thanks to the capability of a new 3.5 MV underground accelerator facility, currently installed at the Ion Beam Facility of the Gran Sasso National Laboratories (LNGS). The challenges and opportunities displayed by this measurement in the new facility will be presented.

Measurements of ^{20}Ne(p, γ)^{21}Na and ^{21}Ne(p, γ)^{22}Na reactions at LUNA experiment.

Casaburo F. per la LUNA Collaboration
Dipartimento di Fisica, Università degli Studi di Genova e INFN, Sezione Genova

Thanks to the natural shield against cosmic rays provided by the Gran Sasso massif, the LUNA accelerator facility made possible several precision measurements of nuclear reactions of astrophysical interest. In the last years, several key reactions of NeNa cycle, active in giant branch stars, novae and supernovae, have been studied. The ^{20}Ne(p, γ)^{21}Na is the slowest reaction in the cycle and directly affects the abundances on Ne and Na isotopes. LUNA studied the $E_r = 386$ keV resonance and the direct capture below $E_p = 370$ keV using a gas target setup and two high-purity germanium detectors. The same experimental setup is currently used for the study of the ^{21}Ne(p, γ)^{22}Na reaction which has a significant role in the ^{22}Na radioactive isotope in novae and supernovae. The experimental details, results on the ^{20}Ne(p, γ)^{21}Na current status of the ^{21}Ne(p, γ)^{22}Na experimental campaign, together with MC simulations, will be presented.

Directly measuring the 65 keV resonance strength of the ^{17}O(p, γ)^{18}F reaction at LUNA.

Gesuè R.M. per la LUNA Collaboration
Gran Sasso Science Institute, L'Aquila, Italy

The ^{17}O(p, γ)^{18}F reaction plays a crucial role in AGB nucleosynthesis as well as in explosive hydrogen burning occurring in type-Ia novae. At the temperatures of interest for the former scenario (20 MK $< T <$ 80 MK) the main contribution to the astrophysical reaction rate comes from the poorly constrained $E_R = 65$ keV resonance. The strength of this resonance is presently determined only through indirect measurements. A new high-sensitivity setup was installed at LUNA, located at LNGS, where the cosmic-ray background is reduced

by several orders of magnitude. The residual background was further reduced installing a devoted shielding. Furthermore the 4π BGO detector was coupled with Al target chamber and holder to increase efficiency. With more than 400 C accumulated on Ta_2O_5 targets the LUNA Collaboration has performed the first direct measurement of the 65 keV resonance strength. In this communication the improved experimental setup will be described, the analysis procedure will be discussed and preliminary results will be shown.

Misura della sezione d'urto della $^{12}C(\alpha,\gamma)^{16}O$ con ERNA.

Santonastaso C. ([1]), Buompane R. ([1])([2]), De Cesare M. ([1])([2])([4]), Di Leva A. ([2])([3]), Garcia Duarte J. ([5]), Gialanella L. ([1])([2]), Formicola A. ([6]), Mitsou M.L. ([1]), Molitierno F. ([1]), Morales-Gallegos L. ([2]), Porzio G. ([1])([2]), Rapagnani D. ([2])([3]), Romoli M. ([1])([2])

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I modelli stellari sono estremamente sensibili al rapporto $^{12}C/^{16}O$ risultante dalla fase di *Helium burning*. La principale fonte di incertezza sulla determinazione di tali abbondanze è dovuta alla reazione $^{12}C(\alpha,\gamma)^{16}O$, la cui sezione d'urto all'energia di interesse astrofisico ($E_0 \approx 300$ keV) è richiesta con una precisione migliore del 10%. Una misura diretta nell'intervallo di energia di interesse non è fattibile a causa della bassa sezione d'urto a E_0 ($\approx 10^{-17}$ b). A causa della complessa struttura dei livelli energetici del nucleo di ^{16}O, l'estrapolazione del fattore astrofisico richiede misure di alta precisione. Il separatore di rinculi ERNA installato presso il laboratorio CIRCE-DMF dell'Università della Campania, Caserta, è stato potenziato per ampliare l'intervallo di energia di misura accessibile fino a 1.0 MeV e per valutare le diverse transizioni che compongono la sezione d'urto della reazione $^{12}C(\alpha,\gamma)^{16}O$. In questa comunicazione verrà illustrato il commissioning del separatore e gli obiettivi della prossima campagna di misura.

Investigating deuterium destruction in BBN with the Felsenkeller accelerator.

Sreekala A.R. ([1])([2]), Caciolli A. ([1])([2]), Bemmerer D. ([3]), Broggini C. ([1]), Bruno C.G. ([4]), Campostrini M. ([5]), Corvisiero P. ([6]), Depalo R. ([7]), Ferraro F. ([7]), Glorius J. ([8]), Lossin T. ([9]), Masha E. ([3]), Menegazzo R. ([1]), Piatti D. ([1])([2]), Rigato V. ([5]), Skowronski J. ([1])([2]), Zavatarelli S. ([6])

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The $^2H(p,\gamma)^3He$ reaction is the dominant process responsible for the destruction of deuterium during the Big Bang Nucleosynthesis(BBN) that changes the primordial deuterium abundance ratio (D/H). D/H ratio can be measured through direct observations at high precision, but theoretical models come up short due to lack of precise measurements of reaction

cross-sections over the whole energy range. In this study, we perform the reaction at the Felsenkeller Underground facility at 5–10 μA, 400 keV to 2 MeV energy using two deuterated targets ZrD_2 and TiD and measure the gamma rays produced with 6 germanium detectors at different angles. The cross-section is measured over a range of energies that covers the low-energy LUNA Collaboration data, too, enabling a comparison through independent setups to reduce uncertainties on the final cross-section. The efficiency of the detectors is calibrated using 4 radioactive sources (^{88}Y, ^{137}Cs, ^{60}Co and ^{22}Na) which covers up to 1.8 MeV, and then extended to higher energies using ^{27}Al(p, γ)^{28}Si. The detector setup also allows a study on the angular distribution of the cross-sections.

AsBeST.

Mitsou M.L. ([1]), Buompane R. ([1])([5]), Gialanella L. ([1])([5]), Santonastaso C. ([1])([5]), Porzio G. ([1])([5]), Nunzio I. ([1])([5]), Canino M. ([2]), Pieruccini M. ([2]), Bidini C. ([2]), Casali N. ([6]), Formicola A. ([6]), Neitzert H.C. ([3]), Laubenstein M. ([7]), Di Leva A. ([4])([5]), Di Benedetto L. ([3]), Rubino A. ([3]), Bellettato M. ([2]), Degli Esposti Boschi C. ([2]), Russo M. ([2]), Bidini C. ([2])

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Il progetto AsBeST (A 7-Beryllium electron capture STudy for nuclear and solid state physics) è finalizzato alla misura della vita media del ^{7}Be, un isotopo radioattivo del berillio, che decade in ^{7}Li per cattura elettronica,la cui probabilità di decadimento può dipendere dalle condizioni al contorno. Questo tipo di misura è di grande interesse per la teoria della struttura nucleare. Inoltre, l'influenza dell'ambiente esterno sulla vita media del ^{7}Be ha conseguenze sulla fisica solare e sulla fisica del neutrino. L'attività sperimentale è basata su due diversi approcci finalizzati a produrre condizioni controllate di perturbazione della densità elettronica del ^{7}Be e alla misura della vita media in tali condizioni. Il primo approccio consiste nella misura della vita media del ^{7}Be mediante la tecnica del decadimento in volo; il secondo approccio si basa sulla misura della variazione del tempo di decadimento del ^{7}Be impiantato in diodi di SiC inversamente polarizzati al fine di sottoporre l'isotopo radioattivo a campi elettrici dell'ordine dei MV/cm. Saranno presentati le tecniche di misura, gli apparati sperimentali e i risultati delle misure ancillari.

Caratterizzazione tubo a raggi X, Tripla GEM e misure di sensitività attraverso il loro utilizzo.

Tamigio A.

Università di Pavia

Il progetto consiste nella caratterizzazione dettagliata di una sorgente di raggi X (MiniX2 X-Ray Tube) e di un rivelatore Tripla GEM al fine di ottenere misure di sensitività attraverso il loro utilizzo congiunto. In primo luogo verranno presentate le caratteristiche del tubo radiogeno utilizzato e come, attraverso il software di simulazione Geant4, siano state svolte sia delle simulazioni di dose assorbita in aria e su persona con differenti schermature in Al, Cu e Pb. Lo scopo di tale studio è stato quello di definire le caratteristiche di una box da costruire attorno alla sorgente che permettesse di lavorare in sicurezza. Successivamente

verrà presentato il rivelatore Tripla GEM mostrando le misure di rate, guadagno e uniformità di guadagno sulla sua superficie svolte inizialmente attraverso l'utilizzo di una o due sorgenti di Fe per poi passare alla sua caratterizzazione con la sorgente di raggi X. Infine verranno mostrati e confrontati i dati relativi alle misure di sensitività ricavati simultaneamente da misure sperimentali e dalle simulazioni effettuate con Geant4, nel quale è stato ricostruito dettagliatamente il nostro setup sperimentale.

Light yield non-proportionality of LYSO scintillator and measurement of the Birks-Onsager quenching parameters.

Nicolaidis R., Nozzoli F., Ghezzer L.E.

Physics Department, University of Trento and Trento Institute of Fundamental Physics and Applications TIFPA-INFN

The scintillation response of a Ce-doped lutetium-yttrium oxyorthosilicate (LYSO) scintillator crystal to gamma rays is investigated and a non-proportionality of the light yield for sub-MeV gamma rays is measured. The effect of the Birks scintillation quenching of relatively slow electrons produced by low-energy gamma ray in the scintillator is investigated with a dedicated GEANT4 simulation to describe the measured light yield non-proportionality. The Birks-Onsager parameters inferred for low-energy electrons with this method are compared with the ones measured in LYSO using multi-GeV nuclei and hundreds-MeV proton beams. This comparison is a powerful probe of the underlying light yield quenching theory. Experimental measurements and result comparisons will be shown.

Space-resolved electron density and temperature evaluation in ECR ion sources plasma by X-ray pinhole camera spectroscopy.

Finocchiaro G. ([1])([2]), Naselli E. ([2]), Mishra B. ([2]), Biri S. ([3]), Mazzaglia M. ([2]), Pidatella A. ([2]), Rácz R. ([3]), Torrisi G. ([2]), Mascali D. ([2])

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X-ray space-resolved spectroscopy can be used to evaluate electron density and temperature distribution in magnetized plasmas. In the PANDORA project a high-resolution full-field X-ray pin-hole camera setup was developed, consisting of a 400 μm hole in a lead disk coupled to a 1MP X-ray CCD camera (1–20 keV energy range). Single-photon-counted (SPhC) and high-dynamical-range (HDR) analysis allowed 560 m and 230 eV @ 8.1 keV of spatial and energy resolution, respectively. Quantitative analysis has been performed on electron cyclotron resonance (ECR) argon plasmas, heated by 200 W microwave power at 14 GHz. Local electron density and temperature have been extracted by the analysis of both the local fluorescence and bremsstrahlung spectra, according to the theoretical emissivity model in the approximation of local Maxwell-Boltzmann electron energy distribution. The analysis method is a powerful tool to investigate the effects of magnetic confinement and the plasma heating dynamics, with relevant implications about R&D of ECR Ion Sources for accelerator physics, as well as for fundamental plasma physics and in-plasma nuclear physics research.

Measurements of the Cherenkov effect in direct detection of charged particles with SiPMs.

Carnesecchi F. ([1]), Sabiu B. ([2])([4]), Strazzi S. ([3]), Vignola G. ([4]), Agrawal N. ([3]), Alici A. ([3]), Antonioli P. ([4]), Arcelli S. ([3]), Bellini F. ([3]), Cavazza D. ([4]), Cifarelli L. ([3]), Colocci M. ([3]), Durando S. ([5]), Ercolessi F. ([3]), Ficorella A. ([6]), Fraticelli C. ([3]), Garbini M. ([7]), Giacalone M. ([3]), Gola A. ([6]), Hatzifotiadou

D. ([3]), Jacazio N. ([3]), Margotti A. ([4]), Malfattore G. ([3]), Nania R. ([4]), Noferini F. ([4]), Paternoster G. ([6]), Pinazza O. ([4]), Preghenella R. ([4]), Rath R. ([4]), Ricci R. ([8]), Rignanese L. ([4]), Rubini N. ([3]), Scapparone E. ([4]), Scioli G. ([3]), Tripathy S. ([4]), Zichichi A. ([3])
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([3]) *Dipartimento di Fisica e Astronomia "Augusto Righi", University of Bologna, Bologna, Italy*
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([6]) *Fondazione Bruno Kessler, Povo, Italy*
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Silicon PhotoMultipliers (SiPMs) are established photon detectors of choice for a variety of applications because of their high efficiency, insensitivity to magnetic fields and low cost. SiPMs are usually coupled to scintillators or Cherenkov chambers. Recently it has been pointed out that SiPMs are also able to directly detect charged particles: indeed, at the passage of a single charged particle, several SPADs (Single Photon Avalanche Diodes), the SiPM unit microcell, are firing. This effect is related to Cherenkov light emission in the protection layer normally placed above the sensor as observed by comparing SiPMs with different, in thickness and material, protection layers and one SiPM without. Beam test results of SiPMs with resin protection layers feature an increased detection efficiency, if compared with a simple geometrical factor, reaching a value around 99%. Moreover, an intrinsic time resolution around 20 ps is measured. This result paves the way for moving SiPMs from simple photosensors to combined charged particles detectors. This possibility would open to applications of SiPMs in many areas, from space experiments to colliders detectors.

Neutron production simulation for Boron Neutron Capture Therapy.

Ferrara N., Iaselli G., Ramos D.
University of Bari and INFN, Bari Division, Politecnico di Bari

This study is focused on the simulation of a new facility for a therapy called Boron Neutron Capture Therapy (BNCT). The facility consists of a proton beam used for protontherapy, a target made of lithium and a Beam Shaping Assembly (BSA). Neutrons are produced from nuclear reaction between lithium target and protons and are moderated by BSA, in order to be clinically feasible for BNCT. In this therapy is crucial to have thermal neutrons, because of the high cross-section value. In fact, Boron Neutron Capture Therapy is a highly selective hadrontherapy, based on the $^{10}\mathrm{B}(\mathrm{n},\alpha)^{7}\mathrm{Li}$ capture reaction. ^{10}B is deposited in the cancer cell via a drug. Subsequently, the patient is irradiated with thermal neutrons producing an unstable ^{11}B nucleus which decays into an α particle and an excited recoil nucleus of ^{7}Li, which de-excites by emitting 478 keV gamma rays. So, thermal neutrons could be obtained from a nuclear reactor, a solution clinically impossible to install near a hospital. In order to produce a clinical neutron beam, neutrons are selected and focused into the treatment zone using a Beam Shaping Assembly (BSA), which consists of a moderator, for neutron thermalization, a filter used to select final energy and a reflector that shapes their direction. This solution uses a protontherapy facility built by Linearbeam s.r.l. company, which has been fully simulated in GEANT4, a simulation toolkit for HEP.

Aula F8 - Maria Marinaro **ore 09:00 – 13:30**

Sezione II
Fisica della materia
Presiede: Sangiovanni G. (Universität Würzburg, Germany)

Relazioni su invito

▲ **A Josephson bipolar quantum heat engine.**
Giazotto F., Germanese G., Paolucci F., Marchegiani G., Braggio A.
NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Pisa, Italy
Thermoelectric effects in metals are typically small due to the nearly perfect particle-hole symmetry around their Fermi surface. Furthermore, thermo-phase effects and linear thermoelectricity in superconducting systems have been identified only when particle-hole symmetry is explicitly broken, since thermoelectric effects were considered impossible in pristine superconductors. Here, we experimentally demonstrate that superconducting tunnel junctions develop a very large bipolar thermoelectricity in the presence of a sizable thermal gradient thanks to spontaneous particle-hole symmetry breaking. Our junctions show Seebeck coefficients of up to $\pm 300\,\mu$V/K, which is roughly 10^5 times larger than the value expected for normal metals at subkelvin temperatures. Moreover, by integrating our junctions into a Josephson interferometer, we realize a bipolar thermoelectric Josephson engine generating phase-tunable electric powers of up to $\sim 140\,$nW/mm^2. Notably, our device implements also the prototype for a persistent thermoelectric memory cell, written or erased by current injection. We expect that our findings will lead to applications in the field of superconducting quantum technologies.

▲ **Study of overdoped $La_{2-x}Sr_xCuO_4$ (LSCO) using electrolyte gating.**
Caruso R. ([1]), Bollinger A.T. ([1]), He X. ([1]), Božović I. ([1])([2])
([1]) *Brookhaven National Laboratory, Upton, NY, USA*
([2]) *Department of Chemistry, Yale University, New Haven, CT, USA*
The demise of superconducting transition temperature in the overdoped region of the phase diagram of LSCO is still one of the open questions in the field of high temperature superconductivity. Several studies have framed this feature in a dirty BCS scenario, where the increased dopant density is increasing the disorder to the point that the pair-breaking becomes dominant and transition temperature decreases. However, experiments on LSCO and other cuprates show that the superfluid density in the overdoped region decreases as doping increases, thus contradicting this dirty-BCS scenario. In our experiment, we tune the carrier density continuously in the overdoped region by means of electrolyte gating. In this technique, an ionic liquid is used to cover the sample and an external gate voltage is applied to obtain higher electric fields compared to standard gate insulator technique. We demonstrate that disorder does not play any significant role in the superconducting transition in this region of the phase diagram, and instead we show evidence of superconducting transition temperature and disorder simultaneously decreasing as doping is increased.

▲ **New insights into quantum spin Hall-based Josephson junctions.**
Traverso Ziani N.
Università di Genova
Josephson junctions based on the Quantum Spin Hall Effect (QSHE) offer a promising playground to manipulate the helical edge states in view of spintronics and superconducting

spintronics applications. Despite an intense research effort, a theoretical model for some experimentally relevant setups was still missing. In this context, I will consider a QSH-based Josephson junction with a constriction between the edge channels. In this system, the transport of Cooper pairs is significantly affected by single-particle effects, and peculiar signatures emerge. In particular, I will show that the relevant flux quantum in the interference pattern doubles, and an anomalous Josephson effect arises in the presence of reconstructed edges. Lastly, I will describe how the Cooper pair injection and the interference oscillations are modified if the edge states are broadly extended across the junction.

Comunicazioni

Magneto-topological transitions and current states in multicomponent superconductors.

Yerin Y. ([1]), Drechsler S.-L. ([2]), Cuoco M. ([3]), Petrillo C. ([4])
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([2]) *Institute for Theoretical Solid State Physics, Leibniz-Institut für Festkörper- und Werkstoffforschung IFW-Dresden, Germany*
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Multicomponent superconductors can host different nonstandard phenomena, such as broken-time reversal symmetry states (BTRS), exotic Fulde-Ferrell-Larkin-Ovchinnikov phases, etc. We show that in the case of a two-component superconducting quasi-one-dimensional channel this catalogue can be extended by a novel inhomogeneous current state, which we have termed as a multiple-momenta state or, in short, a multiple-q state, characterized by the coexistence of two different interpenetrating Cooper pair condensates with different total momenta. Within the Ginzburg-Landau formalism for a dirty two-band superconductor we reveal that under certain conditions, the occurrence of multiple-q states can induce a cascade of transitions involving switching between them and the homogeneous BTRS (non-BTRS) states and vice versa leading this way to a complex interplay of homogeneous and inhomogeneous current states. We demonstrate that the modification of the kinetic energy of superconducting electrons in a doubly connected superconducting cylinder, determined by the applied flux, generally drives transitions from chiral superconducting states to configurations that are time-reversal symmetric.

Signatures of superconducting proximity effects in (2D) (S/F) bilayers with a helimagnetic metal superconductor/ferromagnet.

Spuri A. ([1]), Nikolic D. ([1]), Chakraborty S. ([1]), Belzig W. ([1]), Scheer E. ([1]), Di Bernardo A. ([1]), Steinberg H. ([2]), Millo O. ([2]), Klang M. ([2]), Mandrus D. ([3])
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Several studies performed on three-dimensional (3D) superconductor/ferromagnet (S/F) structures have shown that a viable route to generate fully spin-polarized (*i.e.*, spin-triplet) superconducting states consists in using F materials with an intrinsically inhomogeneous magnetization. We have fabricated 2D S/F bilayers consisting of $Cr_{1/3}NbS_2$ (a F with a magnetically inhomogeneous ground state) stacked via van der Waals interactions onto NbS_2 (2D S) and we have characterized their low-temperature magnetotransport properties to find evidence for spin-triplet states. Our results demonstrate strong evidence for a superconducting proximity effect occurring in the $Cr_{1/3}NbS_2/NbS_2$ system which manifests through the emergence of H-tunable reentrant resistive states below the superconducting

transition of the bilayers and through a non-monotonic variation of the superconducting critical temperature (T_c) with the applied H. The latter result is possibly consistent with the generation of long-ranged spin-triplet pairs at the $NbS_2/Cr_{1/3}NbS_2$ interface.

Inducing or destroying topological phases through dissipation in open quantum systems.

Pavan F. ([1]), Cataudella V. ([2])([3]), de Candia A. ([2])([3]), De Filippis G. ([2])([3]), Di Bello G. ([1]), Perroni C.A. ([2])

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Manipulating topological properties of quantum matter is a key objective in condensed matter physics. A mayor role is played by the interactions, which can affect or modify topological classifications of noninteracting fermion systems in various ways. In this context, it is particularly interesting to consider a topological system coupled with the environment, that is an example of the more general class of open quantum systems. In general, these systems give rise to nontrivial physics described by an effective non-Hermitian Hamiltonian, generalizing the symmetries of topological systems and Altland-Zirnbauer classes of Hermitian Hamiltonians. We consider the well-known SSH model coupled with the environment (described as many independent phonons) through one of the two hoppings of the model. In particular we show that depending on one of the two hoppings and the strength of electron-phonon coupling one can either turn a trivial phase into a topological one or, vice versa, using the interaction within the environment, also inducing an effective non-Hermitian physics. In this way we prove that dissipation is not only detrimental to topology, but can be used to tunate topological phases.

Superconducting qubit network: Physics and applications.

Lisitskiy M. ([1]), Ruggiero B. ([1]), Fistul M. ([2]), Gatti C. ([3]), Il'ichev E. ([4]), Oelsner G. ([4]), Ustinov A. ([5]), Zagoskin A. ([6]), Lisitskiy M. ([1])

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In the present time, there is growing interest in superconducting qubit networks (SQNs) —solid-state systems demonstrating the coherent collective quantum-mechanical dynamics on a macroscopic scale. SQNs appear to be unique systems in which various important factors for potential applications, such as low dissipation and decoherence, electromagnetic field tunable qubit parameters, strong electromagnetic coupling between qubits and a well established measurement setup can be combined. Embedding superconducting qubits in a low dissipative resonator results in a strong coupling between single qubits and cavity photons, which has allowed to observe an entanglement between qubits states. SQNs based on both flux qubits and transmon qubits permit to manipulate quantum states of single qubits at long coherence time and allow the experimental observation of stable collective quantum states. Recently, we propose a novel approach to detect single microwave photons based on a coherent collective oquantum states occurring in SQNs embedded in a low-dissipative

superconducting resonator. SQNs are also most promising systems for the implementation of analog quantum simulation.

Estimation of the relaxation time in NbReN microstrips of different widths for superconducting single photon detectors.

Makhdoumi Kakhaki Z. [1], Leo A. [1], Ejrnaes M. [2], Parlato L. [3], Nigro A. [1], Pepe G.P. [3], Cirillo C. [4], Attanasio C. [1]

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Recently, superconducting microstrips have been proposed as single-photon detectors as an alternative to more sophisticated nanowire structures. In this work, we fabricated by ultra-high vacuum DC magnetron sputtering microstrips of NbReN, a promising material for single-photon detection. We study the nonequilibrium state generated by vortex motion in microstrips with thickness of about 10 nm and widths, w, between 2 and 10 μm. In particular, by analysing the shape of the I-V curves in the flux-flow regime and the dependence of the critical current on the magnetic field we obtain indication on the main pinning mechanisms (edge barrier or bulk pinning) present in the films. Moreover, from the investigation of the instability in the I-V curves, we estimate the vortex critical velocity, v^*, and the quasi-particles relaxation time, τ. The values of these two parameters give further indication of the dominant pinning mechanism. The small value of τ (about 300 ps) obtained for $w = 10$ μm further suggests the potential of NbReN for the realization of superconducting single-photon detectors with large areas obtained by low-cost fabrication techniques.

Excitons at room temperature in a two-dimensional quantum spin Hall insulator.

Consiglio A. [1][2], Syperek M. [3], Stühler R. [2][4], Holewa P. [3], Wyborski P. [3], Dusanowski L. [2][3][4], Reis F. [2][4], Höfling S. [2][4], Thomale R. [1][2], Hanke W. [1][2], Claessen R. [2][4], Di Sante D. [5][6], Schneider C. [7]

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Since the prediction in graphene of quantum spin Hall (QSH) effect, the research field on topological states of matter saw a remarkable increase in interest. A boost came from the verification, in 2007, of this state. Future applications are then made possible by a vanishing bulk conductivity, combined with symmetry-protected helical edge states. To date, however, the use of QSH materials is limited to very low temperatures because of small band gaps. A progress in this direction is made by bismuthene (honeycomb layer of bismuth atoms) grown on a silicon carbide substrate. This material exhibits a direct gap of 1.3 eV at the K-point, proposing itself as an excellent QSH insulator for studying excitons in the visible and near-infrared range. During the presentation the theoretical results on the optical resonances in Bi:SiC, obtained via many-body perturbation theory and Bethe-Salpeter equation, will be

discussed. Together with spectroscopic and ARPES data, it will be shown that the strong electron-hole interaction has indeed a relevant effect on the optical excitations in Bi:SiC. These results provide the first evidence of excitons in a 2D QSH insulator.

Properties of sputtered films of the electron-doped $Nd^{2-x}Ce^{x}CuO^{4-d}$ superconductor.

Nigro A. ([1]), Guarino A. ([2]), Autieri C. ([3]), Marra P. ([4])([5]), Leo A. ([1])([2]), Grimaldi G. ([2]), Avella A. ([1])

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In $RE^{2-x}Ce^{x}CuO^{4-d}$ (RE = rare earth) electron-doped cuprates, the superconductivity is harder to achieve since as-grown samples are antiferromagnetic up to high doping levels, and become superconducting only after a specific annealing process. The role of the annealing treatment still constitutes an open question for n-type superconductors. We investigate the electrical and structural properties of $Nd^{2-x}Ce^{x}CuO^{4-d}$ films grown by a sputtering technique in an oxygen-deficient environment, to obtain information on the complete oxygen-phase diagram. The as-grown samples are non-superconducting, and the structural properties are consistent with a deficiency of oxygen content. Unexpectedly, a reducing thermal treatment at high temperatures can induce superconductivity in these films. Our data support the picture that the high-temperature annealing procedure causes a peculiar oxygen atoms distribution triggering the superconducting transition in these compounds.

Orbitronics effects in spin-singlet superconductors.

Mercaldo M.T.

Dipartimento di Fisica, Università degli Studi di Salerno

We consider a multi-orbital spin-singlet superconductor without inversion symmetry, *e.g.*, due to crystalline asymmetry as well as to electric fields or mechanical strain. The lack of inversion symmetry yields non-trivial orbital-Rashba couplings in the system that affect the electronic orbital texture at the surface leading to a dramatic impact on the superconductivity. We demonstrate that, by varying the strength of the orbital-Rashba couplings, the superconducting phase can be either suppressed, or undergo a 0-π transition, with the π-phase being marked by non-trivial sign change of the superconducting order parameter between different bands. We have also studied the Edelstein effect, finding that the supercurrent-induced orbital magnetization is more than one order of magnitude greater than that due to the spin. Finally, in two-dimensional spin-singlet superconductors with low degree of spatial-symmetry content, we show that a vortex state at zero magnetic field can be energetically stable. The overall findings unveil a rich scenario to design heterostructures with superconducting orbitronics effects for the achievement, for instance, of all-electric superconducting devices.

Tunable 0-π Josephson devices with ferromagnetic insulator barrier: The role of spin-orbit interaction and lattice impurities.

Capecelatro R., Minutillo M., Lucignano P.

Dipartimento di Fisica E. Pancini, Università degli Studi di Napoli "Federico II", Monte S. Angelo, Napoli, Italy

Josephson π-junctions (π-JJs) are currently subject to intense research due to their applicability in superconducting quantum circuits and spintronics. The possible integration of π-JJs in quantum circuits for superconducting qubits is quite promising, paving the way to scalable self-biased devices with increased robustness against magnetic noise and a more compact design. Superconductor-ferromagnet-superconductor JJs (SFS JJs) are promising platforms to implement π-JJs, exhibiting temperature induced 0-π transitions. Much less is known when the ferromagnet is insulating and thus more suitable for quantum circuits, due to its low dissipation. We investigate the transport properties of ferromagnetic-insulator barrier junctions (SFIS JJs) with the aim of finding an effective way to control the 0-π transitions, through a direct action on the temperature behavior of the critical current ($I_c(T)$), that may be used as a fingerprint of the junction. We study the role of impurities as well as of spin orbit in this task. 0-π transitions can be properly tuned, thus achieving stable π-JJs up to the critical temperature, that may be possibly employed in superconducting quantum circuits.

Unconventional superconductivity and modified weak localization induced by chiral molecules adsorption.

Millo O.

Racah Institute of Physics, The Hebrew University of Jerusalem, Israel

We demonstrate that unconventional triplet superconductivity is induced in conventional superconductors upon adsorbing non-magnetic chiral molecules. Scanning tunneling spectroscopy data show that the singlet s-wave order parameter of Nb, NbN and $NbSe_2$ is altered upon the adsorption of chiral polyalanine alpha-helix molecules. The tunneling spectra exhibit zero-bias conductance peaks embedded inside the gap, suggesting the emergence of a triplet-pairing component, corroborated by fits to theoretical spectra. Conductance spectra measured on devices comprising exfoliated $NbSe_2$ flakes over which the molecules sparsely were adsorbed exhibit in-gap states symmetrically positioned around zero bias, behaving under applied magnetic field as Shiba states, akin to the effect of magnetic impurities. Muon spin rotation data exhibit unconventional Meissner screening and a broken time-reversal state upon AHPA adsorption on Nb, and scanning SQUID susceptometry show edge states around adsorbed molecules islands. Further evidence for the magnetic properties these chiral molecules attain upon adsorption serves their unique effect on the weak-localization properties of thin Au and Cu films.

Superconducting behavior of bismuth palladium crystals (BiPd and Bi_2Pd).

Arumugam R. ([1]), Fittipaldi R. ([1]), Guarino A. ([1]), Lettieri M. ([1]), Mayoh D. ([2]), Balakrishnan G. ([2]), Vecchione A. ([1])

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Topological superconductors (SCs) have mostly been realised in fabricated topological phases, such as heterostructures, where the proximity effect induces triplet pairing with conventional s-wave SCs, due to the rarity of triplet pairing. In order to further study Majorana physics and build quantum computers, there has been recently a lot of interest in researching novel quantum materials having spin-triplet Cooper pairs. The study of α-BiPd and β-Bi_2Pd showing respectively non-centrosymmetric and topological superconductivity, is appealing. Single crystals of α-BiPd and β-Bi_2Pd form in monoclinic and orthorhombic crystal systems with space groups $P21$ and $Cmc21$. Here, we describe the characterisation of single crystals of α-BiPd and β-Bi_2Pd grown by optical floating zone approach. Energy dispersive

spectroscopy and electron backscattered diffraction measurements were used to examine the composition and microstructure of the produced crystals. Electric resistivity and susceptibility measurements were performed to study their superconducting behavior.

Characterization of REBCO films and tapes towards energy applications.
Khan M.R. ([1])([2]), Leo A. ([1])([2]), Masi A. ([3]), Pinto V. ([3]), Angrisani Armenio A. ([3]), Augieri A. ([3]), Celentano G. ([3]), Martucciello N. ([2]), Nigro A. ([1])([2]), Grimaldi G. ([2])
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REBCO tapes are being manufactured by multiple companies using unique combinations of materials and deposition processes. To effectively design and use them in power devices, it is important to determine their critical fields and flux pinning characteristics. In this work, electrical transport measurements were performed on commercially available coated conductors. Magneto-resistivity measurements were taken at various angles between coated conductor sample and magnetic field up to 15 T. We determined the flux pinning energy and highlighted its noticeable increase related to the intrinsic contribution of the REBCO lattice structure when a magnetic field is applied parallel to the *ab*-plane. We compared the results of our determination on commercial tapes with the results obtained on films deposited through chemical solution deposition on single crystal substrates. Furthermore, we measured the critical currents of full-size 4 mm wide conductors across a large field range at 4.2 K under the perpendicular applied magnetic field.

Localisation-to-delocalisation transition of moiré excitons in a $WSe_2/MoSe_2$ heterostructure.
Blundo E. ([1]), Tuzi F. ([1]), Cuccu M. ([1]), Cianci S. ([1]), Olkowska-Pucko K. ([2]), Contestabile G. ([1]), Felici F. ([1]), Pettinari G. ([3]), Taniguchi T. ([4]), Watanabe K. ([5]), Babinski A. ([2]), Molas M.R. ([2]), Polimeni A. ([1])
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([5]) *Research Center for Functional Materials, National Institute for Materials Science, Namiki, Tsukuba, Japan*
Moiré excitons (MXs) are electron-hole pairs localised by the periodic (moiré) potential forming in two-dimensional heterostructures (HS). MXs can be exploited, *e.g.*, for creating nanoscale-ordered quantum emitters and achieving or probing strongly correlated electronic phases at relatively high temperatures. Here, we studied the exciton properties of a $WSe_2/MoSe_2$ HS from $T = 6$ K to room temperature using time-resolved and continuous-wave micro-photoluminescence, also under magnetic field. The exciton dynamics and emission lineshape evolution with temperature show clear signatures that MXs de-trap from the moiré potential and turn into free interlayer excitons (IXs) at $T \gtrsim 120$ K. The MX-to-IX transition is also apparent from the exciton magnetic moment reversing its sign when the moiré potential is not capable to localise excitons at elevated temperatures. Concomitantly, the exciton formation and decay times reduce drastically. Thus, our findings establish the conditions for a truly confined nature of the exciton states in a moiré superlattice with increasing temperature.

Unveiling charge transport mechanisms in electronic devices based on defect-engineered MoS_2 covalent networks.

Urban F. ([1]), Ippolito S. ([1]), Zheng W. ([2]), Mazzarisi O. ([3]), Valentini C. ([1]), Kelly A.G. ([4]), Gali S.M. ([5]), Bonn M. ([2]), Beljonne D. ([5]), Corberi F. ([6]), Coleman J.N. ([4]), Wang H.I. ([2]), Samorì P. ([1])

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Solution-processed transition metal dichalcogenides (TMDs) are a hot-topic research trend in printed (opto)-electronics. Liquid phase exfoliation is an efficient strategy to produce thin nanosheets dispersed in a suitable solvent, promoting the advances of printed electronics. However, the device performance is limited by structural defects and poor inter-flake electronic connectivity within the films. The formation of covalent interconnected networks of TMDs represent an efficient strategy to simultaneously heal sulfur vacancies and bridge adjacent flakes, thereby generating percolation pathways for the charge transport, ultimately boosting the electrical performance. Here, we unveil the charge transport mechanisms of printed devices based on covalent MoS_2 networks, by comparing the effects of aromatic *vs.* aliphatic dithiolated linkers. Temperature-dependent electrical measurements reveal hopping as the dominant transport mechanism and a novel analysis of percolation theory underlines the superior performance of π-conjugated networks. Our findings provide valuable guidelines for improving the charge transport properties in MoS_2 devices based on covalent networks.

Aula F4 - Henrietta Leavitt **ore 09:00 – 13:30**

Sezione III
Astrofisica
Presiede: Mercurio A. (Università di Salerno)

Relazioni su invito

▲ **The James Webb Space Telescope: our new window on the Universe.**
Maiolino R.
Department of Physics, University of Cambridge
The successful launch, deployment and commissioning of the James Webb Space Telescope has opened a new era in astronomy and astrophysics. Indeed, in some infrared spectral bands, Webb's sensitivity is up to three orders of magnitude higher than previous facilities. Such a huge leap in sensitivity has happened very rarely in the history of astronomy and, even more broadly, in the history of science. To put it into a context, it is equivalent, in the visible, to suddenly passing from Galileo's telescope to modern 10 m-class telescopes. The first year of observations has certainly not disappointed, revealing several unexpected results. I will give a brief overview of the early, exciting findings obtained with Webb, spanning from the characterisation of exoplanet atmospheres to the detection of new classes of galaxies in the early Universe.

▲ **JWST first results: a revolutionary view of early galaxies.**
Santini P.
INAF - Osservatorio Astronomico di Roma
The launch of the James Webb Space Telescope (JWST) has opened an unprecedented discovery space. Its enormous gain in sensitivity (10–1000×) and spatial resolution (3–7×) compared to its predecessors, combined with its infrared wavelength coverage (0.6–28 micron), are leading to revolutionary results. These first months of observations have been incredibly lively and have brought unexpected findings. If confirmed, these results will likely change our understanding of the galaxy evolution paradigm. I will present the first year of JWST results in the field of galaxy evolution, focusing in particular on the earliest and most distant galaxies.

▲ **Zooming into primordial galaxies and star-forming complexes with JWST.**
Rosati P.
Dipartimento di Fisica e Scienze della Terra, Università di Ferrara
The unprecedented combination of angular resolution, sensitivity and near- and mid-infrared coverage offered by the James Webb Space Telescope is transforming our view on how galaxies form and evolve from their earliest stages. I will report on some highlights in the search and physical characterisation of the most distant galaxies and star-forming complexes, particularly taking advantage of JWST observations of strongly lensing galaxy clusters. Gravitational lensing amplification and magnification allows us to extend to low luminosities and stellar masses (below $10^6 M_\odot$) our knowledge of star-forming systems in the first billion year of cosmic history, resolving their inner structure down to parsec resolution. These studies complement those in the field which have found a surprisingly large number of luminous galaxies at $z > 9$, challenging theoretical expectations. JWST spectroscopic observations of low-luminosity systems are critical to identify the first generation of extremely metal poor stars and ultimately the sources of reionization in the Universe.

Comunicazioni

High-precision strong lensing models of galaxy clusters in the JWST era.

Bergamini P. [1][2], Grillo C. [1][3], Rosati P. [2][4], Acebron A. [1][3], Mercurio A. [5][6], Meneghetti M. [2], Vanzella E. [2], Meštrić U. [1], Granata G. [1][3], Angora G. [4][6], Caminha G. B. [7], Treu T. [9], Nonino M. [8], Castellano M. [10], Fontana A. [10]

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Since its launch, the high angular resolution and sensitivity of the JWST are revolutionizing our way of studying the Universe by allowing for the identification of stellar ensembles up to $z \sim 13$. By combining the JWST data with the magnification power of strong gravitational lensing (SL) by galaxy clusters (GCs), we can further improve the JWST capabilities and resolve sources assembling during the first billion years. In this context, I will present state-of-the-art SL models for the HFF GCs Abell 2744 and MACSJ0416. Both models are constrained by the two largest datasets of multiple images used to date (counting 149 and 237 images) identified by combining the data of the JWST, the HST, and the VLT. The MUSE spectra are used to measure the stellar velocity dispersion of tens of cluster galaxies, which are exploited to independently constrain the subhalo mass component of the GCs. Remarkably, the two SL models have a precision of 0.43" in predicting the positions of the multiple images. Our SL models represent a significant step forward in accurately mapping the GC total mass distributions and play a key role in current and future studies of GCs and magnified high-z galaxies.

Deep-Learning–based search for galaxy-scale lenses in the galaxy cluster environments.

Angora G. [1][2], Rosati P. [1][3][10], Meneghetti M. [3], Brescia M. [2][4], Mercurio A. [2][11], Grillo C. [5][6], Bergamini P. [3][5], Acebron A. [5][6], Caminha G. [7][8], Nonino M. [9], Tortorelli L. [12], Bazzanini L. [1], Vanzella E. [3]

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In the current era of big data, the development of methods able to autonomously extract information from vast multi-dimensional datasets plays a pivotal role. I will present how Convolutional Neural Networks (CNNs) can be trained to select galaxy-galaxy strong-lenses (GGSLs) in galaxy clusters. These systems can be used to characterize the subhalo component of the cluster mass distribution and test ΛCDM structure formation paradigms. Although CNNs have been used to identify GGSL in the field, I will present how these cutting-edge algorithms can be tuned to detect such systems in the dense environment of galaxy clusters. The networks have been trained with simulated GGSLs, where sources have been injected in real HST image cutouts exploiting high-precision cluster-lens models (CLASH and HFF). Observations completely drive the simulation process, preserving the complexity of real data and producing simulated events indistinguishable from the real ones. This approach is extended beyond HST to Euclid mock data and VST imaging. The best CNNs achieve a high purity-completeness level (88%–93%). This methodology is applied to search for GGSLs around 6000 cluster members in 50 clusters.

A new strong-lensing model for the massive galaxy cluster PLCKG287.0+32.9.

D'Addona M. ([1])([2]), Mercurio A. ([1])([2]), Caminha G.B. ([3])([4]), Rosati P. ([5])([6]), Grillo C. ([7])([8]), Bergamini P. ([6])([7]), Angora G. ([2])([5]), Acebron A. ([7])([8]), Granata G. ([7])([8]), Vanzella E. ([6])
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Galaxy clusters are an essential tool to constrain cosmological models and the study of their mass distribution can be used to test the predictions of the currently favoured Λ-CDM model. Cosmological simulations, in fact, produce accurate predictions and any significant deviations from the theoretical expectations would imply that the dynamical history of the hierarchical formation of clusters does not proceed according to the Λ-CDM paradigm, for example, because of a different nature of Dark Matter. In this context, using newly obtained VLT/MUSE spectroscopic data, we present a new strong lensing model of the galaxy cluster PLCKG287.0+32.9, a powerful gravitational lens at $z = 0.38$ for which previous works, based solely on photometry, found a very large Einstein radius $\theta_e > 40''$. The study of this cluster could help to shed some light on the tension between the predictions of Λ-CDM model and observational evidence found in other powerful lenses: being at the highly non-linear tail of the probability distribution of Einstein radii, an accurate lensing model can actually make the difference between a mild outlier for Λ-CDM and a clear challenge.

The Spiderweb protocluster.

Lepore M.
INAF-Osservatorio Astrofisico di Arcetri

Protoclusters are defined as overdense regions in the high redshift Universe which are expected to evolve into massive, virialized clusters of galaxies at the present epoch. Finding

and characterizing protoclusters is key to study the large scale structure of the Universe and the transformational processes that affect star formation and nuclear activity in the member galaxies. In order to confirm their nature and to trace the activity of several processes occurring during their rapid evolution, protocluster candidates must be followed-up with multi-wavelength campaigns. One of the few protocluster intensively studied in the last 25 years is the archetypal Spiderweb Galaxy which lies at the center of a protocluster at $z = 2.16$. Particularly, thanks to X-ray data we are able to study the nuclear emission from the central galaxy and protocluster members and the diffuse emission of the proto-intracluster medium, revealing an enhancement of nuclear activity and, for the first time, the presence of a strong cool core in a halo at $z > 2$. These results have profound implications for the formation and evolution of protoclusters in the Universe.

Relics' revolution: the journey of massive, compact and old galaxies.
Tortora C.
INAF - Osservatorio Astronomico di Capodimonte, Napoli, Italy
Relic galaxies, *i.e.*, massive, compact and old galaxies which have formed most of their stars in a short time are the remnants of high-z red nuggets, which did not merge to form the biggest passive galaxies. The time has finally come: although extremely rare, it is now possible to find them and study their properties in very details. They will provide a unique look at the high-z red nuggets, the stellar populations in the cores of the largest galaxies and the role of mergers and environment on the evolution of the most massive and passive galaxies. I will bring you through the "Relics' revolution", starting from the discoveries of the first relic galaxies in the local Universe, and then I discuss our contribution to the field, with our campaign using KiDS@VST survey and spectroscopic follow-ups to find relic candidates. But we are now approaching the innermost cave, with the INSPIRE ESO large program using XShooter@VLT. Thanks to INSPIRE, we seize the sword: we confirm the discovery of the first 10 relics ever found at $0.15 < z < 0.4$, which add to the only 3 existing in the local Universe. I will finally go through the current state of our project and future prospects.

The inner slope of the mass density profile of clusters of galaxies.
Biviano A., Pizzuti L., Mercurio A., Rosati P., Ettori S., Sartoris B., Girardi M., Grillo C., Caminha G.
INAF-Osservatorio Astronomico di Trieste
I will present observational determinations of the inner slope of the cluster mass density profiles based on data from the CLASH-VLT/Zooming collaboration (P.I.: Piero Rosati). Our results show remarkable consistency with cosmological numerical simulation predictions based on the LambdaCDM model, at variance with previous observational results that claimed a much flatter inner density profile. I will discuss the reason for this difference and present prospects for future developments on this topic.

Investigating the structure of cluster galaxies with combined strong lensing and stellar kinematics.
Granata G. ([1])([2]), Mercurio A. ([3])([4]), Grillo C. ([1])([2]), Tortorelli L. ([5]), Bergamini P. ([1])([6]), Meneghetti M. ([6])([7]), Rosati P. ([6])([8]), Meštrić U. ([6]), Bartosch Caminha G. ([9])
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Strong lensing (SL) is a powerful probe of the dark matter mass distribution in the cores of galaxy clusters, providing us with insights into its nature, and with tests of ΛCDM cosmology. SL models predict an excess of galaxy-galaxy strong lensing (GGSL) events in clusters compared with cosmological simulations: this is reflected by a higher compactness for the observed cluster galaxies with respect to simulations. The mismatch could point towards new physics beyond ΛCDM. In this talk, I will discuss how the determination of the compactness of the cluster members in SL models is hindered by parametric degeneracies, which are broken by studying GGSL events. I will present new SL models for several galaxy lenses within the clusters MACSJ0416 and MACSJ1206. We extend current studies on lens galaxies to lower mass limits and confirm the high compactness predicted for cluster galaxies by recent SL works. Secondly, I will show how enhancing SL models with stellar kinematics allows us to probe the structure of the cluster galaxies. I will present new measurements of the line-of-sight velocity dispersion for several hundreds of members, from deep VLT/MUSE observations of massive clusters.

Relazioni su invito

▲ **The assembly history of galaxies in a cluster environment.**
Iodice E.
INAF-Osservatorio Astronomico di Capodimonte
In this talk I would like to present the study of the Hydra I cluster, at $z \sim 0.012$, based on deep images and integral-field (IF) spectroscopy. Deep images, obtained with VST, allowed to map the galaxy structure out the regions of the stellar halos, to detect the diffuse intra-cluster light components and the population of low-surface brightness (LSB) galaxies (*i.e.*, dwarfs and ultra-diffuse galaxies). In particular, we studied how the LSB galaxies are distributed in the cluster, in order to map the mass assembly of the Hydra I cluster. We discovered that galaxies are grouped in substructures in different regions of the covered cluster area. The non-uniform spatial distribution of galaxies supports the idea that several small galaxies are falling through the cluster core, feeding the cluster mass assembly process. This study motivated a spectroscopic follow-up with MUSE@VLT, entitled "Looking into the faintEst WIth muSe (LEWIS)". With LEWIS we obtained the first homogeneous IF spectroscopic survey of LSB and ultra-diffuse galaxies. This project will be also presented in my talk.

Comunicazioni

● **Stellar halos in ETGs from deep imaging and integral field spectroscopy.**
Spavone M.
INAF-Astronomical Observatory of Naples
The study of galaxies stellar halos and diffuse intracluster light, historically hampered by the faintness of these components, has been fostered by the advent of deep imaging surveys,

which allow to study faint features and galaxiey structures out to their outskirts. In this context, the VST Early-type GAlaxies Survey (VEGAS) is producing competitive results. Therefore, taking advantage of the deep VST images, we can address the build up history of the stellar halo by comparing the surface brightness profile and the stellar mass fraction with the prediction of cosmological galaxy formation. The deep observations can be directly compared with the predictions from the up-to-date theories for the stellar halo formation and the relation with the galaxy environment. Moreover, by combining extended deep imaging and integral-field spectroscopy we can simultaneously map the structure, kinematics, and population properties of the central *in situ* and outer *ex situ* stellar galaxies' components. In this talk I will show the results of studies of galaxies' stellar halos perfomed by using both VST deep images and MUSE integral field spectra.

● **Does the virial mass drive the intracluster Light?**

Ragusa R.
INAF-Astronomical observatory of Capodimonte

The LCDM paradigm suggests that the intracluster light (ICL) in galaxy clusters is formed due to the gravitational interactions that occur during the formation of the Brightest Cluster Galaxies (BCG). As a result, the ICL serves as a fossil record of the mass assembly process in galaxies, and its physical properties (luminosity, color, stellar population, fraction (f_{ICL})), provide insights into the formation mechanisms that contributed to the ICL and the dynamical and evolutionary state of the system. Understanding how the f_{ICL} is related to the virial mass (M_{vir}) of the host environment can help to better understand the physical processes involved in the formation of the ICL. Detecting and studying the ICL is a challenging task due to its low surface brightness and extension, requiring deep imaging and wide field and despite limited measurements of f_{ICL}, no clear conclusion on the correlation with M_{vir} has been established. In this talk, I explore the relationship between f_{ICL} and M_{vir}, as well as f_{ICL} and f_{ETG} ($N_{ETG}/N_{ETG} + N_{LTG}$). This was achieved through a statistically significant and homogeneous sample of 22 groups and clusters ($z < 0.05$), taking advantage of the VEGAS data.

Relazioni su invito

▲ **The impact of extragalactic globular clusters on galaxy formation research: the experience with VST/VEGAS and beyond.**

Cantiello M. ([1]), Hazra N. ([1])([2]), Lonare P. ([1]), Mirabile M. ([1])([2]), Raimondo G. ([1]), Brocato E. ([1])([3])
([1]) *INAF Astronomical Observatory of Abruzzo, Teramo, Italy*
([2]) *Gran Sasso Science Institute, L'Aquila, Italy*
([3]) *INAF Astronomical Observatory of Rome, Rome, Italy*

To understand the formation and evolution mechanisms of galaxies, data must be collected from various observables and accurately interpreted by models or by comparison with reference objects with known properties. Extragalactic globular clusters (GCs) are a particularly efficient tool for studying galaxies. This is due to several properties of these objects. After stars, GCs are probably among the simplest astronomical objects, as they host a (relatively) simple stellar population. The GC system in the Milky Way is an excellent comparative term for systems in other galaxies. They are typically old (age $t \geq 10$ Gyr), bright (so that they can be observed out to large distances) and very numerous (up to tens of thousands in some galaxies). Finally, the study of the GC system in numerous galaxies has revealed many properties that are useful for studying various features of the host environment. In my talk, I will give an overview of the properties of GC systems and the results of their study,

obtained mainly in recent years thanks to the availability of wide-field imaging data from observing campaigns such as the VST Early Type GAlaxies Survey (VEGAS).

Comunicazioni

Exploring the role of extragalactic globular clusters in shaping galaxy formation: insights from VST/VEGAS, MUSE/LEWIS and future prospects.

Mirabile M. ([1])([2]), Cantiello M. ([1]), Iodice E. ([3]), Paolillo M. ([4])
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One way to study galaxies is through their globular clusters (GCs) population. Since GCs host a relatively simple (namely single age and single metallicity) stellar population, they are undoubtedly among the simplest astronomical objects after stars. They are often exceedingly numerous (up to tens of thousands in some galaxies), very old (age $t \geq 10$ Gyr) and luminous (so they may be observed out to large distances). The old age makes the GC system a valuable fossil tracer of the formation of a galaxy. Hence, one possible pathway to understand the mechanisms involved in galaxy formation and evolution is through the analysis of their host GCs system. During my talk I will provide a summary of the main results from my master thesis obtained using data from the VST/VEGAS survey, and preliminary results about GC population in ultra diffuse galaxies obtained within the LEWIS project with MUSE@VLT.

Aula F3 - Maria Telkes **ore 09:00 – 13:30**

Sezione IV
Geofisica e fisica dell'ambiente
Presiede: Cimini D. (IMAA-CNR, Potenza e Università dell'Aquila)

Relazioni su invito

▲ **CAREHeat: DeteCtion and threAts of maRinE Heat waves project.**
Santoleri R. (1), Landolfi A. (1), Organelli E. (1), Bellacicco M. (1), Barros L. (2), Cunha R. (2), De Toma V. (1), di Sarra A. (4), Garcia T. (2), Greiner E. (3), Iacono R. (4), Lefevre F. (3), Marullo S. (4), Napolitano E. (4), Oliveira A. (2), Pisano A. (1), Senina I. (3), Serva F. (1), Verbrugge N. (3), Yang C. (1), Rio M.H. (5)
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Marine Heat Waves (MHWs), persistent and anomalously sea water temperature warm events, are known to have significant impacts on marine ecosystems as well as on air-sea exchanges. Detecting and predicting the occurrence, intensity and duration of these extreme events, and understanding their impacts on marine ecosystems is a key step towards developing science-based solutions for sustainable development. The project "deteCtion and threAts of maRinE Heat waves – CAREHeat", funded by ESA, aims at improving the current MHW detection and characterization methodology, as well as advancing the understanding of the physical processes involved, and the corresponding ecological and biogeochemical changes. This is to be achieved following a multidisciplinary approach capitalizing on the large potential offered by satellite Earth observations, complemented with *in situ* field measurements, physical and biogeochemical ocean reanalyses, biogeochemical modelling and emerging machine learning technologies. In this communication an overview of the CAREHeat project activities and its preliminary results will be provided.

▲ **The 2022–2023 heat wave in the Mediterranean as seen at the Lampedusa Climate Observatory.**
di Sarra A. (1), Anello F. (1), Bommarito C. (1), Cinelli G. (1), De Silvestri L. (1), Di Iorio T. (1), Marullo S. (2), Meloni D. (1), Monteleone F. (1), Pace G. (1), Pecci M. (1)(3), Piacentino S. (1), Sferlazzo D.M. (1)
(1) *Laboratory for Observations and Measurements for Environment and Climate, ENEA, Italy*
(2) *Laboratory Climate Modelling, ENEA, Italy*
(3) *University of Rome Sapienza, Italy*
In the period May 2022–early April 2023 various regions of the Mediterranean were characterized by anomalously high temperatures, associated with an intense and long-lasting atmospheric and marine heat wave taking place in the central and western basins. The wide set of high-quality measurements obtained at the integrated Lampedusa Climate Observatory has been used to characterize the event and investigate the processes which contributed to the heat wave. In particular, linkages between atmospheric and oceanic processes have been investigated. The heat budget components at the surface of the ocean have been calculated using measurements carried out at the Lampedusa Atmospheric and Oceanographic

Observatories, and suggest that the latent heat in particular has played a significant role in determining the heat gain at the surface. Few intense wind episodes, relatively unfrequent during summer 2022, appear to have induced vertical mixing and heat redistribution in the ocean, leading to high ocean temperatures throughout a significant fraction of the water column. Possible connections and influences on the carbon cycle will be also discussed.

▲ **What happens in the deep ocean? Observations, parameterizations and models of the deep ocean and in the Mediterranean.**

Artale V. ([1])([2]), Giambenedetti B. ([1])([3]), Lo Bue N. ([1]), Falcini F. ([2]), Kokoszka F. ([4])

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The exchange between the ocean's turbulent surface boundary layer and the underlying stratified water column can occur over a wide range of timescales. On the other hand, deep water takes many decades to return to the surface, acting as reservoir of heat and CO_2, contributing to the climate decadal variability. The bottom dynamics has been re-evaluated in recent papers, in which the interplay between downward and upward energy propagation has updated the original vision of Munk (1966). The Mediterranean basin is a good example to explore this physical (upside-down) mechanism. Recently, in the Ionian Sea, a significant positive shift of the ocean heat content between 2000 and 4000 m has been observed during thirty years, from 1977 to 2011. This intriguing heat storage is due to the bottom-driven mixing processes, produced by the ventilation of the deep layers of two different deep-water sources, originating from the Adriatic and the Aegean, respectively. From the above, we intend to discuss the role of the deep mixing in the abyssal circulation in the Mediterranean Sea, considering new *in situ* data exploring the deep dynamics and modeling results.

▲ **The Climate Change Tower Integrated Project (CCT-IP) and the muldisciplinary observing activities of Italy at Ny Alesund (Svalbard) since 2009.**

Vitale V. ([1]), Mazzola M. ([1]), Viola A. ([1]), Gilardoni S. ([1]), Barbaro E. ([1]), Salvatori R. ([1]), Salzano R. ([2]), Spolaor A. ([1]), Lupi A. ([1]), Becherini F. ([1]), Vardè M. ([1]), Petkov B. ([1])([5]), Tampieri F. ([1]), Traversi R. ([3]), Becagli S. ([3]), Severi M. ([3]), Cappelletti D. ([4]), Moroni B. ([5]), Rinaldi M. ([6]), Paglione M. ([6]), Langone L. ([1]), Miserocchi S. ([1]), Giordano P. ([1]), Giglio F. ([1]), Tesi T. ([1]), Doveri M. ([7]), Giamberini S. ([7]), Augusti A. ([8]), Gavrichkova O. ([8]), Azzaro M. ([1]), Guglielmin M. ([9]), Cannone N. ([9]), Verazzo G. ([1])

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The relaunch in 2008–2009 of the Italian activities at the Arctic CNR station Dirigibile Italia (DI) in a broadly multidisciplinary key will be widely presented in terms of conceptual approaches and overall strategy. In the last 15 years, observing activities have been widely expanded and diversified, extending and integrating the three multidisciplinary observation

platforms implemented between 2008 and 2010 as part of the "Climate Change Tower Integrated Project" (CCT-IP). The development of the observing program always followed the dual objective of contributing to the growth of Ny Alesund as an observing super-site, and allowing us to observe and study the Kongsfjorden area in an Earth System Science perspective. The main research topics developed in recent years will be presented through some of the most important results achieved by the different research groups that contributed and are contributing to this integrated effort. The importance of international collaboration will be also highlighted. Finally, the possible prospects in the short and medium term for the Italian research activities in Ny Alesund and Svalbard area, also as contribution to SIOS, will be presented/proposed.

▲ **Extremes and anthropogenic climate change in the Mediterranean basin.**

Lionello P.

Department of Biological and Environmental Sciences and Technologies, DiSTeBA, University of Salento

Climatic and meteorological extremes are a broad and diverse category of phenomena, generally defined on the basis of low probability, which have negative consequences on ecosystems and societies. Climate change has already impacted extreme temperatures and, in addition to further increasing heatwaves, is expected to increase the intensity of extreme rainfall, droughts and coastal flooding. Different processes are responsible for varying different extremes. However, the increase in saturation water pressure as a function of temperature in the atmosphere plays a role in many of them. The increased evaporative capacity of a warmer atmosphere increases evapotranspiration from the continental surface and in combination with reduced precipitation results in longer and more intense ecological droughts (lack of moisture in the soil). This in turn exerts a positive feedback on heatwaves by reducing evapotranspiration cooling of continental surfaces. The higher water content of a warmer atmosphere is also the basis for the increase in extreme precipitation. This communication analyses these processes and their relevance in the Mediterranean basin.

▲ **CMIP6 GCM validation based on ECS and TCR ranking for 21st century temperature projections and risk assessment.**

Scafetta N.

Università degli Studi di Napoli "Federico II"

Global climate models (GCMs) from the sixth Coupled Model Intercomparison Project Phases (CMIP6) have been employed to simulate the twenty-first century temperatures for the risk assessment of future climate change. Here, I rank 41 CMIP6 GCMs according to how successfully they hindcast the reported 0.5–0.6 °C global surface warming from 1980 to 2021 using both their published ECS and TCR estimates. The sub-ensemble of GCMs with the best performance appears to be composed of the models with ECS ranging between 1.8 and 3 and TCR ranging between 1.2 and 1.8 °C, which would imply that only the low-sensitivity models might be realistic. However, alternative climatic records (*e.g.*, the low troposphere ones, comparison between land and ocean regions, and temperature proxy models) appear to suggest that the actual surface global warming from 1980 to date could have been 30% less, which would imply that surface records are too contaminated by urban heats and other local non-climatic biases. As a result, the real global aggregated impact and risk estimates seem to be moderate, which implies that any negative effects of future climate change may be adequately addressed by adaptation programs.

Comunicazioni

Has the frequency of Mediterranean Marine Heatwaves really increased in the last decades?

Marullo S. ([1]), Serva F. ([2]), de Toma V. ([2]), Pisano A. ([2]), Iacono R. ([1]), Napolitano E. ([1]), Di Sarra G. ([1]), Meloni D. ([1]), Sferlazzo D. ([1]), Bellacicco M. ([2]), Landolfi A. ([2]), Organelli E. ([2]), Yang C. ([2]), Santoleri R. ([2])

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Marine Heat Waves (MHWs) are events of prolonged anomalously warm water, in portions of the oceans, which have severe impacts on the local marine ecosystems. In a climate change scenario, with increasing temperatures and more frequent atmospheric extreme events, the frequency and intensity of the MHWs are expected to increase. In such a scenario, the choice of the long-term baseline used to compute SST anomalies in such a non-stationary system, becomes a critical issue, since it can significantly affect the frequency and intensity of the events. Here, we critically address the problem of how to characterize and define MHWs in the present warming climate scenario by evaluating the impact of different SST climatic baselines, and the effects of removing climate trends from the original SST time series. We focus on the Mediterranean Sea, a hot spot region for climate change, where a strong mean SST increasing trend (about 0.045 °C/year) has been observed in the last 40 years. This case study focuses on examining the conditions during 2022/2023 and the sensitivity of the detection under different preprocessing methods that account for trends and climate variability.

Drivers of persistent marine heatwaves in the Mediterranean in recent years.

Serva F. ([1]), Marullo S. ([2]), Di Sarra G. ([2]), Iacono R. ([2]), Meloni D. ([2]), Napolitano E. ([2]), Pisano A. ([1]), Sferlazzo D. ([2]), Bellacicco M. ([1]), Landolfi A. ([1]), Organelli E. ([1]), de Toma V. ([1]), Yang C. ([1]), Santoleri R. ([1])

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The Mediterranean basin has experienced several marine heatwaves (MHWs) over the last few decades. During MHWs anomalous warm ocean temperatures are present for several days at least and can influence atmospheric circulation and negatively affect ecosystems. There is increased interest in these events as they occurred more frequently and with larger severity, fuelled by global warming trends. Here we examine the strong Mediterranean MHW of 2022, which started in May and lasted for several months until spring 2023. This MHW phenomenon rapidly spread through western and central Mediterranean with peak intensity at par with the record-breaking 2003 event. In this communication we focus on the drivers of the prolonged 2022/2023 case which led to its exceptional duration. We find that persistent anticyclonic conditions, that continued through fall and winter, were responsible for the persistence of the 2022/2023 MHW. We also discuss recent Mediterranean conditions by analyzing near real-time observational products, and discuss the possible impacts of global warming on MHW characteristics.

Using machine learning in geophysical data assimilation —Some of the issues and some ideas.

Carrassi A.

University of Bologna

In this communication I will present some of the recent developments in the area of data assimilation and machine learning for climate science. In particular I will discuss novel

merged algorithms DA-ML and present applications in ideal systems as well as in models and dataset of the Arctic sea-ice.

The Hunga Tonga-Hunga Ha'apai stratospheric eruption of 15th January 2022: A global warming volcanic plume?

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The underwater Hunga Tonga-Hunga Ha'apai (HT) volcano erupted on 15th January 2022 and injected volcanic gases and aerosols to over 50 km altitude. In this communication, we synthesise satellite, ground-based, *in situ* and radiosonde observations of the eruption to investigate the emissions, dispersion and strength of the stratospheric aerosol and water vapour perturbations in the first year after the eruption. We find that the HT eruption produced the largest global perturbation of stratospheric aerosols since the Pinatubo eruption in 1991 and the largest perturbation of stratospheric water vapour observed in the satellite era. Using offline radiative modeling driven by aerosol and water vapour observations, we quantify the radiative impact of the eruption. Immediately after the eruption, water vapour radiative cooling dominates the local stratospheric heating/cooling rates, producing a spectacular radiatively driven plume descent of several km. Water vapour heating dominates the top-of-the-atmosphere radiative forcing, leading to a net warming of the climate system. This is the first time a climate warming effect is linked to volcanic eruptions, which usually produce a transient cooling.

Future climate scenarios in indoor environment for preventive conservation of cultural heritage in unconditioned historical buildings in the Mediterranean area.

Frasca F., Verticchio E., Matè D., Giammusso F.M., Sebastiani M.L., Sclocchi M.C., Siani A.M.

Physics Department, Sapienza University of Rome

Indoor climate in historic buildings without air conditioning systems results from the interaction between the building envelope and the outdoor climate forcing. Any change in outdoor climate can affect the indoor one, playing a key role in the deterioration of cultural heritage. The long indoor/outdoor climate measurements collected in the State Archive in Palermo (Italy) were used to assess the buffering role of the building envelope to the outdoor climate. Assuming that the building envelope features negligibly change over time, it was set a heat transfer function to reconstruct future indoor climate from outdoor climate ones. To this purpose, three Shared Socio-economic Pathways (SSPs) from the 6th Assessment Report of the Intergovernmental Panel on Climate Change were considered. Thereafter, it was studied whether future indoor climate might favour deterioration mechanisms affecting vulnerable materials (*e.g.*, cellulose-based, wood). The expected persistence of warm conditions in the site according to SSP5-8.5 could favour both chemical reactions and temperature-dependent adult insects' proliferation up to three times more than current conditions.

Estimating climate extreme indices and the related uncertainties using U.S. Climate Reference Network (USCRN) near-surface temperatures.

Essa Y.H. ([3])([4]), Madonna F. ([1])([2]), Marra F. ([2]), Serva F. ([5])([6]), Gardiner T. ([7]), Sarakhs F. ([1]), Rosoldi M. ([2])

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Changes in the frequency of temperature extremes are often attributed to global warming. The availability of near-surface temperature records from reference networks enables the quantification of measurement uncertainties. In this communication, four climate extreme indices (Frost Days, Summer Days, Ice Days, Tropical Nights) and the related uncertainties are calculated for the period 2006–2020 from U.S. Climate Reference Network (USCRN) and compared with traditional indices. Moreover, the asymmetric USCRN uncertainties are propagated to estimate the uncertainties of climate indices. The result shows expanded uncertainties homogeneously distributed with the latitude. Positive uncertainties are larger than negative ones for all the indices. The values of Frost Days and Ice Days with the related uncertainties for USCRN have also been compared with the corresponding values calculated from reanalysis data, showing differences within 60 days for median values, quite often smaller than USCRN and inconsistent within the related uncertainties. Overall, the results show that USCRN measurement uncertainties increase confidence in the estimation of climate extreme indices and decisions for adaptation.

Daily precipitation and temperature extremes in southern Italy (Calabria region).

Prete G. ([1]), Avolio E. ([2]), Capparelli V. ([1]), Lepreti F. ([1])([3]), Carbone V. ([1])([3])

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We apply extreme value theory (EVT) to study the daily precipitation and temperature extremes in the Calabria region (southern Italy) mainly considering a long-term observational dataset (1990–2020) and also investigating the possible use of the ERA5 (ECMWF Reanalysis v5) fields. The efficiency of the EVT applied on the available observational dataset is first assessed both through a punctual statistical analysis and return-level maps. Two different EVT methods are adopted, namely the peak-over-threshold (POT) approach for the precipitation and the block-maxima (BM) approach for the temperature. The proposed methodologies appear to be suitable for describing daily extremes both in quantitative terms, considering the punctual analysis in specific points, and in terms of the most affected areas by extreme values, considering the return-level maps. Conversely, the analysis conducted using the reanalysis fields for the same time period highlights the limitations of using these fields for a correct quantitative reconstruction of the extremes while showing a certain consistency regarding the areas most affected by extreme events.

Statistical analysis of the connection between galactic cosmic rays and atmospheric and land climate variables.

Karimian F., Madonna F.
Department of Physics, University of Salerno, Salerno, Italy and National Research Council of Italy-Institute of Methodologies for Environmental Analysis, CNR-IMAA, Potenza, Italy

By ionizing the air, Galactic Cosmic Rays (GCR) help to form aerosols that may grow into cloud condensation nuclei (CCN), which are required for water droplets to condense and create low-altitude clouds with a consequent cooling effect on the Earth's climate. This communication investigates the indirect effect of GCRs on different atmospheric variables. The parameters used in the analysis are GCR flux, sunspot number (SSN), geomagnetic (AA) index, CO_2, CH_4, cloud liquid water path, cloud effective radiation, aerosol optical depth (AOD), and Earth radiation budget as the predictor variables and near surface temperature as the response variable. Monthly means of GCR count rates from two neutron monitors (NM), one at mid-latitude (Newark, New York) and another at high-latitude (Oulu), are employed along with *in situ* (ICOS/FLUXNET for CO_2 and CH_4, BSRN/SURFAD for radiation), ground-based (AERONET for AOD), and satellite (for cloud properties) measurements. Linear and multiple linear regression models, including collinearity, are used for the analysis. The correlation between GCR and leaf area index (LAI) is also discussed, but to indirect effects that GCRs may have on soil and vegetation.

Assessment of long-term relationship between surface albedo and near surface temperature in grassland dominant region in the United States.

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([1]) *National Research Council of Italy, CNR-IMAA, Potenza, Italy*
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Surface albedo (or albedo) directly affects the energy balance of the Earth and its climate feedbacks, leading to global climate change. Albedo and temperature are considered as thermo-physical parameters which characterize the heat absorption behavior of an area. The present research work aims at examining the long-term relationship between near surface temperature (NST) and albedo in a grassland dominant region in the United States. To this purpose, U.S. Climate Reference Network (USCRN) temperature data and Copernicus PROBA and SPOT-Vegetation albedo data in the period 2006–2020 are used. The directional (black-sky) albedo over visible band [0.4–0.7 μm], near infrared band [0.7–4 μm] and total spectrum [0.4–4 μm] are considered. The monthly mean of albedo and NST are computed to study their relationship and trend. The findings of this research work are useful for improving climate models and applications considering albedo as a proxy of NST in grassland dominant areas.

The magnetism of leaves and lichens for monitoring and mitigating the impact of particulate matter in urban and cultural heritage settings.

Winkler A. ([1]), Boldrighini F. ([2]), Chaparro M. ([3]), Grifoni L. ([1])([4]), Lapenta V. ([5]), Loppi S. ([4]), Marte F. ([6]), Pensabene Buemi L. ([7]), Russo A. ([2]), Spagnuolo L. ([1]), Strano G. ([2]), Tascon M. ([6]), Sgamellotti A. ([5])
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([7]) *Peggy Guggenheim Collection, Venice, Italy*

Particulate matter (PM) can show remarkable magnetic properties arising from magnetite-like ferrimagnetic particles, often associated with heavy metals. In urban areas, motor vehicles represent the main source of magnetic PM, mostly emitted by disk brakes. Rock magnetism can be applied to the biomonitoring of the airborne pollution, using leaves and lichens as efficient bioaccumulators of anthropogenic dust. Here, we will discuss the role of the magnetic biomonitoring methodologies applied to cultural heritage settings, where PM causes, e.g., dark layers, abrasion of materials and artistic loss. Biomonitoring techniques were firstly applied at Villa Farnesina, Rome. Lichen exposure was preceded by the sampling of plant leaves outside the Villa and inside its gardens: trees and shrubs are important for their role in removing air pollutants, providing ecosystem services for the protection of cultural heritage. Further investigations are going on at Parco Archeologico del Colosseo and Terme di Diocleziano in Rome, at Peggy Guggenheim Collection in Venice and at selected National Museums in Buenos Aires, for assessing the impact of PM on various cultural heritage urban contexts.

Aula F7 - Giovanna Mayr **ore 09:00 – 13:30**

Sezione V

Biofisica e fisica medica

Presiede: Bouzin M. (Università di Milano Bicocca)

Relazioni su invito

▲ **Investigating genome plasticity at the nanoscale.**

Farabella I. ([1]), Nir G. ([2]), Lee S.D. ([3]), Marti-Renom M.A. ([4])([5])([6])([7]), Wu C.-T. ([3])([8])

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Recent advances in image-based 3D genomics techniques have enabled single-cell omics analysis in a spatially resolved manner in intact cells. One such approach is sequential-OligoSTORM (seq-OligoSTORM), which couples the use of Oligopaints probes to achieve super-resolution via single-molecule localisation microscopy. Coupling seq-OligoSTORM with our suite of modelling and analysis tools, we visualised and quantified structures ranging in size from tens of kilobases to over one megabase, detailing the variation in chromatin arrangement at the nanoscale in single nuclei. Focusing on chromosomal regions at the megabase scale, we identified chromatin arrangements that can predict whether regions correspond to active (A-type) or inactive (B-type) compartments. This outcome suggests that variation in patterns of chromatin folding may ultimately reflect specific signatures.

▲ **Complexity in humans and pathogens: impact on emerging epidemics.**

Poletto C.

Department of Molecular Medicine, University of Padova, Padova, Italy

The SARS-CoV-2 pandemic has shown the threat modern emerging viruses pose to society. Efficient epidemic management requires situational awareness and deep knowledge of the drivers of virus propagation. Epidemics are non-linear phenomena. Human-to-human interactions, forming the substratum of the infection spread, are heterogeneous and multiscale. Therefore, complexity science represents the essential framework to interpret observations. Modeling approaches from network theory and statistical mechanics allow us to address problems of both conceptual and practical relevance: from identifying the conditions for the large-scale spread of a pathogen to predicting the spatiotemporal pattern of diffusion. During the talk, I will present recent works on emerging pathogen events, including the analysis of recent epidemics and pandemics (*e.g.*, COVID-19 pandemic) and theoretical studies of the mechanisms driving pathogen dynamics.

▲ **Novel perspectives on the human brain modeling.**
Curti N., Carlini G., Biondi R., Remondini D., Castellani G.
Dept. of Physics and Astronomy, University of Bologna (^{BO})
The study of the human brain has been a subject of fascination for scientists and thinkers for centuries. However, with the recent advances in technology and a deeper understanding of neurobiology, novel perspectives on the functioning of the human brain are emerging. These new approaches involve examining the brain as a dynamic and adaptable organ that responds to various environmental and social stimuli. It emphasizes the importance of factors like plasticity, neurogenesis, and epigenetic modification in shaping the brain's development and function. Moreover, these novel perspectives recognize the importance of considering individual differences and diversity in brain functioning, rejecting the one-size-fits-all approaches that dominated earlier research. A deeper understanding of the brain's dynamic nature can guide the artificial intelligence community in developing reliable and interpretable models. Furthermore, a mathematical formalism for the modeling of the human brain and its functioning is essential for a rigorous and objective description of the underlying brain processes.

Comunicazioni

● **Combining biocomputing and deep learning with differentiable neuronal partner selection.**
Boccato T. ([1]), Ferrante M. ([1]), Duggento A. ([1]), Toschi N. ([1])([2])
([1]) *Department of Biomedicine and Prevention, University of Rome Tor Vergata, Rome, Italy*
([2]) *A.A. Martinos Center for Biomedical Imaging and Harvard Medical School, Boston, USA*
The advent of foundation models, such as ChatGPT and DALL·E, has transformed the AI landscape. However, current deep learning algorithms face challenges, including scalability, extensive computational requirements, and significant power consumption. The nascent field of biocomputing aims to overcome these limitations by utilizing 3D brain cell cultures in neural networks (NNs). Yet, training such neuronal networks remains an unresolved issue. We devised a differentiable function for neuronal partner selection, enabling the mapping of neuron expression patterns and genetic interactions onto the synaptic weights of artificial NNs with arbitrary directed, acyclic computational graphs. This approach allows practitioners to employ backpropagation for training a NN on a specific task, optimizing its topology, and concurrently determining the ideal combination of expression patterns and genetic rules. Consequently, a brain organoid could be theoretically pre-trained for a particular task. Our novel framework was used to successfully training a 256-neuron network on the Gym Cart Pole environment using deep reinforcement learning, demonstrating its efficacy and potential impact.

● **Integrating biological learning strategies into machine learning with plasticity-optimized neural networks.**
Angelini G. ([1]), Toschi N. ([1])([2]), Duggento A. ([1])
([1]) *Department of Biomedicine and Prevention, University of Rome Tor Vergata, Rome, IT*
([2]) *A.A. Martinos Center for Biomedical Imaging, MGh and Harvard Medical School, Boston, USA*
Spike-timing–dependent plasticity (STDP) is a biological mechanism that adjusts the strength of synapses based on the timing, recurrence, and directionality of spikes between connected neurons. STDP is a critical learning mechanism in the mammalian brain, and researchers have recently investigated its potential to improve artificial neural network (ANN)

performance. While biologically inspired STDP mechanisms have been widely used in 3rd-generation spiking neural networks (SNNs), STDP is currently underutilized in 2nd-generation classical neural networks due to a lack of accessible tools for incorporating it into ANN training mechanisms. In this study, we present a Pytorch implementation of STDP as an optimizer and extensively characterize the behavior and performance of both 2nd- and 3rd-generation NNs with respect to STDP parameters. Our study shows that STDP can be integrated into machine learning workflows to enhance performance by strengthening connections based on coordinated activations during training. Our Pytorch implementation of STDP can help bridge the gap between machine learning and biological simulations, enabling the exploration of biological learning strategies.

A theoretical framework for understanding proteins.

Škrbic T. ([1]), Banavar J.R. ([2]), Giacometti A. ([1]), Hoang T.X. ([3]), Maritan A. ([4])
([1]) *Department of Molecular Sciences and Nanosystems, Ca' Foscari University of Venice, Venice, Italy*
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([4]) *Department of Physics and Astronomy, University of Padua, Padua, Italy*

Proteins, molecular machines of life, are complex with myriad degrees of freedom. Linus Pauling used quantum chemistry to predict the structures of protein modular building blocks, helices and strands assembled into sheets. Pauling and others adopted a backbone-based view, focusing on the importance of the backbone atoms, the avoidance of steric clashes, and hydrogen bonds. An alternative side chain centered view pointed out the additional vital importance of the role of the solvent, distinct hydrophilic/hydrophobic character of amino acid chains, and the need to sequester the hydrophobic core from the solvent. I will present the results of ongoing work to reconcile these two approaches. Protein building blocks are space-filling structures. Using mathematical and physics ideas, we work out an interaction energy which promotes these structures, as well as a solvent-mediated attraction that correctly assembles the building blocks, while respecting their individual symmetries. Our approach deftly avoids the use of quantum chemistry, is in accord with experimental data, underscoring the consilience in the fit of chemistry and biology to the dictates of mathematics and physics.

Implementazione di modelli per la dinamica del Ca^{2+}.

Musotto R. ([1]), Wanderlingh U. ([2]), D'Ascola A. ([3]), Catania M.V. ([4]), Spatuzza M. ([4]), Pioggia G. ([1])
([1]) *Consiglio Nazionale delle Ricerche (^{CNR}) , Instituto per la Ricerca e l'Innovazione Biomedica (^{IRIB}) , Messina, Italia*
([2]) *Università degli studi di Messina, Dipartimento di Fisica, Messina, Italia*
([3]) *Università degli studi di Messina, Dipartimento di Medicina Clinica e Sperimentale, Policlinico Universitario, Messina, Italia*
([4]) *Consiglio Nazionale delle Ricerche (^{CNR}) , Instituto per la Ricerca e l'Innovazione Biomedica (^{IRIB}) , Catania, Italia*

Nel presente lavoro vengono riportati gli esiti di uno studio volto a chiarire le dinamiche dei segnali astrocitari del Ca^{2+} intracellulare congiuntamente ai meccanismi che ne determinano il comportamento nello spazio e nel tempo. Più specificatamente l'impiego integrato della Microscopia a fluorescenza e di marcatori specifici hanno reso possibile la rilevazione dei cambiamenti relativi degli ioni Ca^{2+} intracellulari. Al fine di analizzare l'intensità media del segnale di fluorescenza in seno alle sequenze di immagini acquisite, è stato impiegato il

software Imagej con il quale sono state individuate le regioni di interesse (ROI) per ogni cellula. Sono state quindi determinate le tracce corrispondenti alla variazione di Ca^{2+} per ogni astrocita e, grazie alla compilazione di script specificatamente approntati, ne sono stati caratterizzati i profili. Infine, l'applicazione di modelli computazionali ha permesso di simulare il comportamento dinamico degli ioni Ca^{2+} intracellulari e di metterne a confronto le risposte in cellule astrogliali sane e patologiche.

Studies of diffusion of Covid-19 on latitude.

Nassisi V. ([1])([2]), Alifano P. ([2]), Calcagnile M. ([2]), Tredici S.M. ([2])
([1]) *Department of Mathematics and Physics, University of Salento, Lecce, Italy*
([2]) *Department of Biological and Environmental Sciences and Technologies, University of Salento, Lecce, Italy*

We analyse the incidence of Covid-19 as a function of latitude and in particular on the temperature variation during the morning up, and in the afternoon down, and other factors that justify the spread of the pandemic in the world and in Italy. The pandemic peaks as a function of latitude correspond around -25 (°) and $+50$ (°). Similar results are also confirmed in 2022 and 2023. Therefore, after more than three years of the Covid pandemic, there are enough data to study the cyclicality of the contagion. We have studied the cyclicality of daily cases and new cases. For Italy, the total cases present an exclusively positive dependence on latitude. It was compared with other cyclicality and with the occurrence of different variants.

Aula F5 - Hildred Blewett **ore 09:00 – 13:30**

Sezione VI
Fisica applicata, acceleratori e beni culturali
Presiede: Ciotti M. (ENEA, Frascati)

Relazioni su invito

▲ **Cosmic Ray Labs —Irradiation facilities in Italy for the qualification of devices for space.**
Latronico L.
INFN, Sezione di Torino
L'Istituto Nazionale di Fisica Nucleare sviluppa sensori ed elettronica ad elevata funzionalità per misure di fisica fondamentale in ambienti ad elevata densità di radiazione, quali collisori ad altissima intensità per lo studio di eventi rari in fisica delle particelle e telescopi per la radiazione cosmica —carichi, X e gamma— nello spazio. INFN ha parallelamente sviluppato competenze ed infrastrutture dedicate alla creazione dei fasci di particelle necessari sia per la generazione degli eventi da rivelare sia per la qualifica dei dispositivi di misura negli ambienti rappresentativi del loro utilizzo. Insieme ad ENEA, che vanta simili competenze e risorse nel campo degli apparati radiogeni, INFN mette a disposizione una rete di acceleratori e fasci di particelle che permettono di simulare le molteplici condizioni di intensità e tipologia di irraggiamento tipiche dello spazio extra-terrestre, al fine di consentire la verifica del livello di maturità tecnologico dei dispositivi proposti per le missioni spaziali, a carattere sia scientifico sia tecnologico o applicativo. Il contributo illustra lo stato dei laboratori e le caratteristiche dei fasci disponibili nella rete, creata in coordinamento con l'Agenzia Spaziale Italiana e accessibile tramite un portale dedicato.

▲ **ECR ion sources and ion traps for accelerators, nuclear astrophysics and applications.**
Mascali D.
Isituto Nazionale di Fisica Nucleare, Laboratori Nazionali del Sud, Catania, Italy, Centro Siciliano di Fisica Nucleare e Struttura della Materia, CSFNSM, Catania, Italy e Università degli Studi di Catania, Dipartimento di Fisica e Astronomia, Catania, Italy
R&D activities on plasma-based Electron Cyclotron Resonance Ion Sources (ECRIS) have boosted particle accelerators performances for decades. Recently, the PANDORA project has tried to broaden the research horizons of these setups, proposing for the first time to investigate the β-decay in ECR plasmas. It is expected that the lifetime of many isotopes (*e.g.*, ^{176}Lu, ^{134}Cs, ^{94}Nb) can dramatically change, even of orders of magnitude, in high-temperature plasmas resembling some astrophysical conditions. These measurements are relevant, for example, to "re-calibrate" the so-called Cosmo-chronometers, or to improve the calculation of elemental abundances in the Galaxy due to the *s*-process nucleosynthesis. Advanced plasma modelling, as well as the development of sophisticated multi-diagnostics devices operating in the RF, microwave, optical and X-ray ranges, are now allowing to characterize plasma properties with unprecedented spatial and energy resolution. The gained expertise and know-how are supporting synergic activities for the Thermonuclear Fusion, especially, contributing to the DTT-Divertor Tokamak Test facility, and the PNRR initiatives named SAMOTHRACE and NQSTI.

Comunicazioni

Investigating metals' content and oxidation states in liquids using XRF analysis with VOXES X-ray spectrometer.

Manti S., Miliucci M., Scordo A., Bedogni R., Clozza A., Moskal G., Piscicchia K., Porcelli A., Sirghi D., Curceanu C.
INFN, Laboratori Nazionali di Frascati, Italy

X-Ray Fluorescence (XRF) is a valuable analytical technique for investigating the properties of metals. The MITIQO project is focused on using XRF to identify the metals' content and oxidation states in various edible products, with a particular emphasis on liquids such as wine and oil. In this study, we showcase the MITIQO experimental apparatus at the INFN laboratory of Frascati, based on the VOXES X-ray spectrometer, with a focus on the identification of the oxidation state of iron. As a first outcome of the project, we demonstrated the capability of MITIQO to establish the correct oxidation state of the iron present in a liquid sample. This research opens up new possibilities like using XRF to analyze the concentration and oxidation state of metals in edible liquids, which has important implications for food safety and quality control.

Chemical-physical and dosimetric characterization of PVA mixtures for Fricke gel dosimetry.

Santangelo C. ([1]), Locarno S. ([1]), Piazzoni M. ([1]), Pignoli E. ([2]), Lenardi C. ([1]), Gallo S. ([1])
([1]) *Dipartimento di Fisica Aldo Pontremoli, Università degli Studi di Milano, Italia*
([2]) *Fondazione IRCCS Istituto Nazionale dei Tumori, Milano, Italia*

Fricke gel (FG) dosimeter is a promising technique because it is a 3D dosimeter suitable for relative dose measurements and it is particularly useful for dose verification in complex clinical situation. It consists of a radiation sensitive chemical and a hydrogel matrix that acts as mobility reducing agent. This one could be based on natural polymers (*e.g.*, gelatine or agarose) or synthetic polymers. Among them, Poly(vinyl-alcohol) (PVA) have shown the best results in terms of dosimetric properties. Nevertheless, the molecular weights and the degree of hydrolyzation of PVA influence the sensitivity and diffusion coefficient of FG. The aim of this work is, indeed, the in deep investigation of how the chemical characteristics of PVA influence the hydrogel matrix in terms of both chemical-physical and dosimetric response. In particular different mixtures of PVA at various w/w percentages are fully characterized according to dosimetric and chemical-physical assessment (*e.g.*, viscosity, gel fraction, swelling test, young modulus and compressive strength) and they are compared with the currently used PVA to find the best hydrogel formulation for FG dosimetry applications.

Optimization of photomobile polymer films' production by ZnO nanoparticles and silver nanocuboids doping.

D'Avino A. ([1]), Sagnelli D. ([1]), Vestri A. ([1]), Rippa M. ([1]), Marchesano V. ([1]), De Girolamo Del Mauro A. ([2]), Loffredo F. ([2]), Villani F. ([2]), Nenna G. ([2]), Ratto F. ([3]), Ambrogi V. ([4]), Petti L. ([1])
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Among smart materials, photo-mobile polymers (PMPs) based on liquid crystals are the most promising in the field of photo-responsive actuators. Indeed, they are realized with

a mixture of liquid crystals containing azobenzene moieties able to photo-isomerize from *trans* to *cis* under UV light. Photoisomerization leads to a macroscopic bending of PMPs transforming light into mechanical energy. To enhance the PMPs actuation, a novel liquid crystal nanocomposite is proposed in the frame of the UE FET PULSE-COM and Eureka investor funded POC ALICE projects. In our work, we used a facile and effective approach to enhance the quantum yield of azobenzene and to extend its wavelength sensitivity by doping the PMP matrix with either ZnO NPs or Ag NPs. These doped PMP films showed faster and more significant bending under both UV as well as visible and NIR light regardless of whether it was coherent, incoherent, polarized and unpolarized irradiation. This demonstrates the potential of these doped PMP films for producing sunlight-sensitive devices such as photomechanical actuators and a new generation of harvesting systems.

Development of a multi-technique setup based on a liquid anode X-ray source for the characterization of materials.

Picollo F. ([1])([2])([3]), Re A. ([1])([2])([3]), Marabotto M. ([1])([3])([4]), Vigorelli L. ([1])([3])([4]), Alessio A. ([1])([2])([3]), Guidorzi L. ([1])([3]), Donazzolo C. ([1]), Lo Giudice A. ([1])([2])([3]), Truccato M. ([1])([2])([3])

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In the last decades, a novel technology for X-ray sources based on the use of a liquid anode has been developed, in order to increase the maximum achievable brilliance by at least one order of magnitude compared to conventional microfocus sources. With this innovative equipment, a High-Brilliance X-ray laboratory (HiBriX Lab) is under development at the University of Turin, hosted at the NIS Inter-departmental Centre. It was designed by integrating different detectors and focusing optics to represent a unique laboratory in Italy and with a handful of comparable examples in the world. The aim is to cover several applications such as: material characterization via μXRD and μXRF maps; investigation of detector performances (charge collection efficiency and damage effects); single cell level radiobiology; X-ray imaging (radiography and tomography) of objects having a wide size range. This work is funded by: RESOLVE project (INFN), PLaMeRaX and BiophysiX projects (CRT Foundation), SAX project (Regione Piemonte), "Departments of Excellence" (L. 232/2016) project (Italian MIUR), SAXSAB and HiBriX Lab (University of Torino and Compagnia di San Paolo Foundation).

On a method for reconstructing potential fields with an application to superresolution microscopy.

Annunziato M. ([1]), Borzì A. ([2])

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A method for the reconstruction of a potential field is presented. This method is based on the observation of stochastic trajectories of particles moving on the field subject to a drift given by the minus gradient of the potential and to a Brownian motion. The reconstruction technique is formulated as an inverse problem governed by the Fokker-Planck equation of the stochastic process and a best-fit functional with a Tikhonov regularization. This optimization problem is solved on a sequence of time windows, allowing to determine the potential together with an estimate of its uncertainty. An application is presented concerning the reconstruction of a cell membrane, based on data of superresolution microscopy of luminescent activated proteins.

Bacterial viability in different atmospheric conditions: Experimental approach and results at the Atmospheric Simulation Chamber ChAMBRe.

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ChAMBRe (Chamber for Aerosol Modelling and Bio-aerosol Research) is a stainless-steel Atmospheric Simulation Chamber, ASC, installed and developed at the National Institute of Nuclear Physics in Genoa in collaboration with the Laboratory for Environmental Physics of the Department of Physics (UniGe). ChAMBRe has been designed to study the bacterial composition and the behavior of microorganisms in the atmosphere. Here we present the results of a set of experiments using *Escherichia coli*, a Gram-negative bacterium, cultured and subsequently aerosolized in the ASC. The survival rate of the bacteria is initially evaluated in "clean air" conditions (baseline), by comparing the concentrations of total bacteria (measured by a WIBS-NEO spectrometer) with the concentrations of viable bacteria, obtained from the colony forming unit (CFU) count, actively collected on Petri dishes by an Andersen impactor. These experiments have been replicated by exposing the bacteria to different concentrations of atmospheric pollutants (NO_2, NO, O_3), observing bacteria viability with respect to the baseline conditions.

Effect of carbon black on the photomobile properties of liquid crystal polymers with or without azobenzene moieties.

Loffredo F. ([1]), De Girolamo Del Mauro A. ([1]), Villani F. ([1]), Caso M. F. ([1]), Fasolino T. ([1]), Miscioscia R. ([1]), Vestri A. ([2]), Sagnelli D. ([2])([1]), D'Avino A. ([2]), Petti L. ([2]), Nenna G. ([1])
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In this work we studied the possibility to induce or modify the photomobile properties of liquid crystal polymers by introducing different concentrations (from 0 up to 1 wt.%) of carbon black (CB) in several polymers containing or not azobenzene mesogens. These units can undergo a reversible photoisomerization from *trans* to *cis* configuration in the presence of UV light by inducing bending in the corresponding films. The morphological and optical properties, as well as the photomobile behaviour of pristine and composite films were investigated and compared. Concerning the photomobile properties, photoresponsivity measurements were studied in the wavelength range 457–747 nm to investigate how the presence of the CB affects the photomobile response inside and outside the absorption spectral region of LC-polymers. Choosing appropriately the CB concentration, we demonstrated that it is possible to induce photomobile behavior in non-active polymers or enlarge the usable spectral bandwidth of the azo-benzene–based samples in visible region towards the visible and near infrared spectral region. The work was supported by the UE FET PULSE-COM and Eureka investor funded POC ALICE projects.

Printing of ZnO seed layers to grow ZnO nanowires on flexible substrates for piezoelectric applications.

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Recently, the industrial interest towards portable and wearable electronics has significantly stimulated the development of innovative devices based on flexible piezoelectric transducers.

Among the semiconductors piezoelectric materials, zinc oxide nanowires (ZnO NWs) have particularly attracted the attention of the scientific community especially in sectors as energy and sensing. Anyway, the growth method of ZnO NWs is still crucial to further extend their applications to flexible devices and the main challenges are the process temperatures and the patterning under vacuum free conditions. In the frame of the UE PULSE-COM project we grew by chemical bath deposition high-quality ZnO NWs on polymeric substrates starting from printed seed layers constituted of ZnO nanoparticles. Using Piezoresponse Force Microscopy we observed that the Zn-polar domains are homogeneously distributed at the top surface of the ZnO NWs. The comparison with the results obtained with seed layers deposited by conventional Atomic Layer Deposition method highlights the key benefit of the printing techniques, moving towards the possibility of manufacturing completely vacuum-free flexible piezoelectric devices.

Study of electrosprayed molybdenum trioxide for photonics and protective coatings.

Azizinia M., Gunnella R., Rezvani S.J.
Università di Camerino

The electrospraying technique is employed to create thin films of molybdenum trioxide (MoO_3) on various substrates. Each parameter linked with the process is meticulously scrutinized to determine the optimal value for each. Different methods of analysis including optical microscopy, Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM), Raman spectroscopy and X-ray Photoelectron Spectroscopy (XPS) are employed to study the deposited thin film samples. The findings verify the existence of deposited MoO_3 and are consistent with previous research. Ultimately, the deposited films will be utilized in organic solar cells to evaluate their efficiency relative to the ones in which MoO_3 thin film (as hole collector) is produced through spin-coating.

Electrospun spinel-structured high-entropy oxide nanofibers as electrocatalysts for oxygen evolution in alkaline medium.

Santangelo S. ([1])([4]), Triolo C. ([1])([4]), Schweidler S. ([2]), Lin L. ([2]), Pagot G. ([3])([4]), Di Noto V. ([3])([4]), Breitung B. ([2])
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Water electrolysis powered by renewable sources is the greenest way to produce H_2, a promising energy vector that could help bring the World to net zero emissions in the coming decades. However, the slow kinetics of the oxygen evolution reaction (OER) represents a limitation for its broad market penetration. Spinel transition metal oxides have shown great potential as a sustainable alternative to precious metal-based electrocatalysts. In this communication, electrospun spinel high-entropy (Cr, Mn, Fe, Co, Ni), (Cr, Mn, Fe, Co, Zn) and (Cr, Mn, Fe, Ni, Zn) oxide nanofibers (NFs) are evaluated as OER electrocatalysts in 1 M KOH solution.$(Cr_{0.2}Mn_{0.2}Fe_{0.2}Co_{0.2}Ni_{0.2})_3O_4$ NFs outperform not only $(Cr_{0.2}Mn_{0.2}Fe_{0.2}Co_{0.2}Zn_{0.2})_3O_4$ and $(Cr_{0.2}Mn_{0.2}Fe_{0.2}Ni_{0.2}Zn_{0.2})_3O_4$ NFs, but also IrO_2 reference electrocatalyst (Tafel slopes: 49.1, 62.5, 59.6 and 52.9 mV/dec, respectively). The higher concentration of oxygen vacancies on their surface and the higher occupation of octahedral sites by redox-active Co^{2+} and Ni^{2+} centres are responsible for their behaviour.

In silico models predicting how photoactivated curcumin's nanocarriers can improve fruits shelf life.

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One of the most dramatic problems in recent years is reducing food waste, *e.g.*, improving its shelf life. In this context, nanotechnology can contribute by producing edible coatings able to gradually release antibacterial substances on food. In the present communication, curcumin nanocrystals in β-cyclodextrin and curcumin in chitosan-shelled nanobubbles are considered as natural and edible coatings for high-added values fruits. Indeed, curcumin has antibacterial and antioxidant properties, further enhanced by photoactivation with blue light, which induces the formation of Reactive Oxygen Species against a large variety of bacteria. The release of curcumin and its activation must be calibrated to avoid both wastes of materials and side effects Indeed, an excess of it or of irradiation could stress the food, while a too-small quantity would not allow the antibacterial effect. To optimize curcumin's concentration, irradiation time, and type of carrier, *in silico* models can be used. The use of two different models will be discussed: Higuchi's, suitable for diffusion processes, and Hopfenberg's, suitable for dissolution ones.

Aula P1 **ore 09:00 – 13:30**

Sezione VI
Simposio di Optometria
Presiedono: Bussa M.P. (Università di Torino)
Montagnoli G. (Università di Padova)

Relazioni su invito

▲ **Surface wetting and friction of Kalifilcon A, a novel silicone-hydrogel contact lens.**
Ponzini E. ([1])([2]), Trabattoni S. ([1])([2]), Stendardo L. ([1]), Antonini C. ([1]), Borghesi A. ([1])([2]), Zeri F. ([1])([2]), Tavazzi S. ([1])([2])
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In contact lens (CL) wear, wettability and friction ensure comfort. Their role is even more relevant when the glycocalyx is damaged or absent, increasing the shear stress during blinking. The manufacturer declares that the composition of the novel silicone hydrogel (SiHy) Kalifilcon A and of its blister solution are designed to retain hydration and a smooth wettable surface, also in subjects suffering from CL discomfort and dry eye symptoms. Based on these considerations, Kalifilcon A was compared *in vitro* with other CLs (two SiHys, two Hys) in a condition of reduced hydration, mimicking a 6 hour wear. To consider the effect of blister solutions, CLs were analysed after a brief rinse and after a 24 hour incubation in saline solution. The results suggest that the wettability of Kalifilcon A is mainly influenced by its SiHy composition. For all CLs, the wettability was worse after incubation than after a brief rinse. In turn, in terms of friction, there is no clear difference both between SiHys and Hys, and between rinsed and incubated CLs. The friction properties of Kalifilcon A are not affected by the incubation, showing an intermediate coefficient when compared to the other CLs.

Comunicazioni

● **Non-Invasive breakup time: Automatic computerized vs. manual assessment.**
Zeri F. ([1])([2])([3]), Rizzo G. C. ([1])([2]), Ponzini E. ([1])([2]), Tavazzi S. ([1])([2])
([1]) *Dipartimento di Scienza dei Materiali, Università degli Studi di Milano-Bicocca, Italia*
([2]) *Optics and Optometry research center, COMiB, Università degli Studi di Milano-Bicocca, Italia*
([3]) *College of Health and Life Sciences, Aston University, Birmingham, UK*
Non-invasive, objective, and automatic assessments of the tear film using keratography are quickly spreading in clinical optometry and ophthalmology. However, few studies have investigated the differences between manual non-invasive breakup time (NIBUT) procedures and the new automatic computer-based ones. This study evaluated the agreement between automatic and manual NIBUT. Eighty-five videos of NIBUT (6.6 ± 3.6 s; range 0–17 s) performed by Sirius+ (CSO, Florence) were selected from the COMiB database. One optometrist recently graduated (Junior) and one optometrist with more than 20 years of experience (Senior) assessed the videos in random order, measuring the NIBUT three times in a row. A significant correlation between automated and manual NIBUT (average of two observers) was

found (Spearman Rho = 0.9; $p < 0.001$), but also a significant statistical difference between the two measurements (Wilcoxon test; $p < 0.01$), although clinically negligible (0.3 s). The Senior observer produced a slightly longer average NIBUT (0.9 s), conversely, the Junior one measured a slightly shorter NIBUT compared to the automatic procedure (0.3 s).

Implementation of a compact optical architecture for visual psychophysical tests based on spatial light modulators.

Ruffato G. ([1]), Scalvini C. ([1]), Battaglini L. ([2])
([1]) *Department of Physics and Astronomy "G. Galilei", University of Padova*
([2]) *Department of General Psychology, University of Padova*

Spatial light modulators (SLM) are increasingly used as active optical elements for wavefront manipulation in holography, adaptive optics, and beam shaping. In this communication, we present the implementation and test of a compact optical system based on a computer-controlled SLM to perform psychophysical tests on visual acuity and contrast sensitivity. The Fourier transform of the desired patterns, *e.g.*, Snellen optotypes or Gabor gratings, are encoded and uploaded on the SLM and customized in terms of final size, contrast, orientation, and position. The device is controlled with specific software in order to conduct psychophysical tests and converge quickly towards a threshold estimate. Thanks to its versatility and scalability, the platform can be extended straightforwardly to any visual test, and preliminary analyses on a group of individuals are here shown and discussed.

The effects of scattered light in the eye: A preliminary study on a glare-based test.

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Glare causes a loss of efficiency in visual acuity, but its effects are often underestimated although it can generate a decrease in visual acuity even greater than high ametropias. The main reason for this effect is the scattered light inside the eye, the phenomenon that affects the electromagnetic wave when it encounters an obstacle or non-homogeneity. Visual perception is severely influenced in this process, because scattered light creates a veil of luminance that worsens the quality of the image. The Light Scatter Test, developed by City University of London, used here is non-invasive and it helps to understand the risks and the visual impairment caused by glare. This work allowed us to show how the age factor has a crucial influence on the amount of scattered light. The test proved to be reliable, confirming the expected data and showing the need for further studies to spread greater awareness of these issues within the scientific community and society, as well as being the basis for further developments in the scientific, medical and technological fields.

Morpho-mechanics of collagen superstructures revealed by Brillouin-Raman microspectroscopy.

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Brillouin and Raman spectroscopy are established optical techniques for the nondestructive contactless and label-free readout of mechanical, chemical, and structural properties of condensed matter. These techniques, coupled with confocal microscopy, have recently gained renewed interest in 2D and 3D mapping of viscoelastic properties and molecular composition of biological matter. Here we report some recent advances of a multimodal scanning

technique, the Brillouin-Raman micro-spectroscopy, for biomedical applications with a focus on the morpho-mechanical analysis of cornea tissues.

Sensitivity and specificity evaluation of refractive condition self-assessment.
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([5]) *School of Life and Health Sciences, Aston University, Birmingham, UK*
The self-report questionnaires could be used as alternative tests to detect refractive errors, although objective and subjective refraction are considered the gold standard procedure. This study evaluated the sensitivity and specificity, of two self-questionnaires (Q1 and Q2) to identify refractive status. The Q1 required to identify refractive error by only scientific term: myopia, hyperopia, astigmatism and presbyopia. In Q2, the options combine the scientific term with a descriptive explanation. A multicenter, randomized double-blind study was conducted. Two hundred eight participants completed one of two questionnaires before a non-cycloplegic eye examination by an optometrist. Sensitivity and specificity were determined comparing the self-reported responses with the classification obtained from subjective refraction. For myopia, the Q1 and Q2 reported a good sensitivity and specificity. The relationship between the operating characteristics of Q1 and Q2 was evaluated by the ROC curve. Both the questionnaires used in the study resulted reliable for identifying myopia although they were not highly accurate for the identification of the remaining visual defects.

Subjective measurement of peripheral refraction.
Colandrea C., Bussa M.P., Serio M., Greco M., Gastaldi M., Chenis A., Di Benedetto S., Bellatorre A.
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The quality of the peripheral image affects several visual aspects. In particular, eye shape, determined by peripheral refraction, has been shown to be an important factor associated with refractive error in children. For this reason, analysis of off-axis refractive error is one of the subjective measurements that should be performed during refractive procedures. Peripheral refraction refers to the position of the focal point of light radiation reaching the eye when horizontal rays are focused on fovea, outside primary visual axis. Recent studies have found that peripheral refractive error plays an important role in the development of myopia: myopic individuals show hyperopic defocus unlike emmetropes or hyperopes, who have myopic defocus at the peripheral level; thus, in order to focus objects located in the peripheral visual field on the retina, the bulb is prone to elongation. The aim of the study was to develop a method for measuring peripheral refraction, accessible to all clinicians without special instruments, and that can be performed during the refractive examination to obtain an additional finding in addition to the central refractive data.

Relazioni su invito

Acuità visiva e sensibilità al contrasto in una stanza illuminata da luce monocromatica.
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Nella mostra tenuta a Palazzo Strozzi a Firenze intitolata "Oleafur Eliasson: Nel tuo tempo" l'artista contemporaneo Olafur Eliasson ha allestito una sala interamente illuminata da lampade a scarica a vapori di sodio a bassa pressione, realizzando così un ambiente illuminato in maniera virtualmente monocromatica gialla. Oltre all'aspetto artistico, è stato realizzato un laboratorio che fondazione Strozzi ha messo a disposizione di CNR INO e Università di Firenze. Sono state condotte misure di sensibilità al contrasto e di acuità visiva su 25 soggetti sia nella sala monocromatica sia in una sala di confronto illuminata in maniera tradizionale. Anche se nella sala monocromatica l'aberrazione cromatica doveva essere assente e veniva chiesto ai canali cromatici un lavoro minore, non si è visto un miglioramento nelle misure effettuate, anche se i soggetti riportavano sensazioni differenti. Tali misure permettono di effettuare considerazioni anche su situazioni diverse, come ad esempio l'utilizzo di lenti filtranti per migliorare la sensibilità al contrasto.

Comunicazioni

Illusioni ottiche come potenziali test optometrici.

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Le illusioni ottiche sono ampiamente utilizzate nell'ambito dell'intrattenimento e dell'arte ma costituiscono anche dei potenti strumenti per fare luce sui fondamenti della percezione umana. Molte di queste illusioni si sono dimostrate un potenziale ambito di lavoro per l'individuazione e la misura di alterazioni e differenze interindividuali che coinvolgono l'intero processo della visione, dall'elaborazione ottica fino a quella cognitiva. All'interno di questo scenario di ricerca in rapida evoluzione, vogliamo discutere come alcune illusioni siano utilizzabili come potenziali test optometrici. Ci concentreremo su due aspetti. 1) La creazione di "immagini ibride", che fanno uso della sovrapposizione di diverse immagini utilizzando una diversa gamma di frequenze spaziali, come strumento per la misura dell'acuità visiva. 2) Le illusioni ottiche che coinvolgono l'illusione di profondità per la misura della stereoacuità. Riteniamo che questo approccio "non convenzionale" possa essere un supporto di grande interesse, soprattutto in screening su una popolazione infantile.

The impact of smartphone luminance on reading abilities.

Grasso P.A., Gurioli M., Boccardo L.
Department of Physics and Astronomy, School of Optics and Optometry, University of Florence

The use of smartphones has become ubiquitous in our daily lives. A large body of literature is focusing on understanding the effects of their prolonged use while another part is exploiting their popularity to develop more and more reliable remote examination of users' visual habits and ocular health. Here we investigated the impact of different levels of smartphone screen luminance on reading performances. The aim was to depict the relation existing between the use of different levels of luminance and the character size at which participants of different ages and different refractive conditions reach a comfortable level of reading. We developed a smartphone version of the Radner Reading Charts with which participants were tested at three levels of luminance (*i.e.*, 37 cd/m^2, 16 cd/m^2, 7 cd/m^2). Reading acuity and velocity were computed and related with demographic and refractive conditions. Our data show that decreased levels of luminance had a robust impact on reading acuity. As expected, age matters with younger individuals being less affected than older ones. Interestingly we also found a trend towards a larger effect on hyperopic individuals.

Blue light and near infrared: Protecting the eyes from potentially harmful radiation.

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Department of Physics and Astronomy "G. Galilei", University of Padova

Ultraviolet (UV) spectrum is commonly believed to represent the most dangerous radiation for the eyes, as it is appropriately identified among the principal causes of cataracts, photokeratitis, and conjunctival diseases. Therefore, wearing additional filtering protection is recommended, especially when exposed to sunlight. However, less attention is usually paid to the near-UV region of the visible spectrum or to the near-infrared (IR) range. As a matter of fact, exposure to blue light can contribute to the long-term accumulation of damage that speeds up the aging process of the retina and promote age-related macular degeneration. Concurrently, also near-infrared radiation up to 1500 nm is not sufficiently filtered by the eye and could result harmful to the retina especially when the intensity is too high. We present here and discuss a few case studies concerning the transmittance analysis of commercial ophthalmic lenses and sunglasses, focusing on their filtering power in the blue region of the visible spectrum down to 350 nm and the IR-A region up to 1.5 μm.

Comparison of tear film stability assessment procedures by non-invasive and fluorescein tear breakup time measurement.

Tavazzi S. ([1])([2]), Rizzo G. C. ([1])([2]), Ponzini E. ([1])([2]), Zeri F. ([1])([2])([3])
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We evaluated agreement and reliability of tear non-invasive breakup time (NIBUT) performed with different devices and with respect to fluorescein procedure (fBUT). Data were collected on 43 subjects (17 males; age range: 18–29 years). NIBUT was measured in a random order with different devices: EasyTear (ET), Polaris (PO) and Sirius (SI). At the end fBUT was acquired. The whole procedure was repeated (retest) 2 hours after the last measurement. BUT (s) was $12.0 \pm 7.6, 12.8 \pm 6.8, 14.8 \pm 8.0, 8.7 \pm 5.2$ in the right eye (RE) and $12.0 \pm 8.2, 14.1 \pm 9.8, 15.6 \pm 7.8, 8.6 \pm 5.0$ in the left eye (LE) with the ET, PO, SI and fBUT, respectively. ANOVA showed a significant difference between measures. All paired comparisons between BUT values were significantly different, except for ET *vs.* PO (RE) and PO *vs.* SI (LE). All correlations between NIBUT procedures resulted statistically significant. All procedures showed no difference between test and retest and ICC resulted higher for NIBUT devices with respect to fBUT. In conclusion fBUT was significantly shorter than NIBUTs. Devices cannot be considered interchangeable; however, they showed similar test-retest reliability.

Teaching efficacy of role playing in optometrist education.

Bussa M.P., Serio M., Colandrea C., Tudorachi V.I.
Physics Department, University of Turin, Turin, Italy

Simulation of the double role of ametrope and practitioner is a usual procedure for students in optometry clinical practice, but it is usually limited to the performance of visual assessment procedures, and the Lecturer's control is focused on these. In contrast, the way in which the practitioner builds the relationship with the ametrope, a key step in obtaining their cooperation during the measurement, is not given specific attention. This pilot project aims to test the effectiveness of the role playing in creating and developing the interaction between ametrope and professional. The project in the first phase allows the teacher to verify through videorecording, the behavior of the pairs of students simulating the two roles

and then to critically analyze it with the students themselves; there is also an evaluation through questionnaires of the self-perception reported by the students involved. In a second phase, the project plans to reevaluate through questionnaires how self-perception has been changed by the critical analysis of the video recordings collected in the first phase, with or without possible rotation of roles.

Development and test of a compact optical device for the measurement of polarization threshold perception based on Haidinger's brushes.

Ruffato G., Caichiolo F., Mottes J., Sorgenfrei C., Montagnoli G., Ortolan D.
Department of Physics and Astronomy "G.Galilei", University of Padova

Haidinger's brushes are an entoptic phenomenon consisting in the perception of a yellowish bow tie in the presence of linearly polarized white light. The pattern arises from the peculiar spatial distribution of dichroic carotenoid molecules in the macula, forming a sort of embedded radial polarizer for blue light in the fovea. We present here the latest results in the development and test of a compact and robust optical device for the measurement of the polarization threshold based on the perception of Hadinger's brushes and discuss possible applications to the early diagnosis of macular diseases.

Connubio tra fisica e neuroscienze nell'analisi visiva.

Pirotta A.
Università di Milano-Bicocca

Il complesso sistema della visione abbraccia diverse competenze che lo specialista deve maturare in differenti ambiti disciplinari. Fondamentale è il contributo della fisica, soprattutto con l'ottica geometrica nel calcolo della corretta lente oftalmica per la gestione dell'ametropia. Lo scopo è convogliare sulle retine la luce che entra nei nostri occhi. D'altro canto la gestione e l'interpretazione delle informazioni visive coinvolge circa due terzi del nostro cervello con differenti processi neurofisiologici che gestiscono l'attenzione visiva, la coordinazione oculare, la percezione spaziale e l'identificazione delle immagini. Abilità decisamente più difficili da misurare e quantificare ma che l'optometrista ha necessità di considerare per indirizzare al meglio le sue possibilità di intervento. Si vedrà sommariamente il processo della visione nelle sue caratteristiche riconducibili ad un approccio fisico e ad uno neurofisiologico. Considerando che le informazioni neurali viaggiano sotto forma di potenziali elettrochimici anche l'aspetto neuroscientifico non può prescindere dal contributo della fisica.

Aula F2 - Ginestra Giovene Amaldi **ore 09:00 – 13:30**

Sezione VII
Didattica e storia della fisica
Presiede: Immè J. (Università di Catania)

Relazioni su invito

▲ **Ascoltare, sperimentare e riflettere insieme - Idee per uno sviluppo professionale personalizzato degli insegnanti di fisica.**
Pantano O.
Dipartimento di Fisica e Astronomia, Università di Padova, Padova, Italia
Negli ultimi anni, il nostro Gruppo di ricerca in Didattica della Fisica e dell'Astronomia all'Università di Padova ha attivato diversi corsi di formazione annuali con gli insegnanti della scuola secondaria di II grado su varie tematiche: "CoLLabora - a Community of Learners on LABORAtory work" sull'uso del laboratorio nella didattica della fisica; "ATENA - Asiago Teachers' Network on Astrophysics" sull'integrazione tra astronomia e fisica; "Fisicamente al Liceo" sullo sviluppo delle abilità matematiche in fisica. L'impostazione comune di questi corsi di formazione, sviluppata a partire dal 2018 nel corso CoLLabora, è quella della comunità di apprendimento, in cui insegnanti e ricercatori non solo collaborano insieme nella progettazione e sperimentazione di Teaching-Learning Sequences (TLS), ma anche si confrontano e riflettono insieme sui bisogni specifici di ciascuna realtà scolastica, individuando il percorso di ricerca-azione più adatto. In questo contributo sono presentati gli elementi comuni di questi corsi di formazione e sono discussi gli effetti attesi sull'innovazione della didattica della fisica sul territorio sul medio e lungo periodo.

▲ **Tra storia, didattica e società: il progetto PEACE.**
Montalbano V. ([1])([2])([3])
([1]) *Dipartimento di Scienze Fisiche, della Terra e dell'Ambiente, Università di Siena, Siena, Italia*
([2]) *INFN, Sezione di Pisa, Pisa, Italia*
([3]) *Associazione per l'Insegnamento della Fisica, sezione di Siena, Siena, Italia*
Il progetto Progettare E Animare Comunità Educanti (PEACE) ha fatto riconoscere stereotipi di genere e promosso nelle scuole senesi di ogni ordine e grado azioni volte al superamento delle loro conseguenze nella vita delle ragazze. Un modulo di formazione per insegnanti di scuola secondaria nelle STEAM ha permesso di confrontarsi sulla disparità di genere e sulle conseguenze nelle vocazioni scientifiche. Si sono individuati aspetti centrali su cui intervenire: far conoscere agli insegnanti elementi di storia della scienza ed esempi vissuti attuali che evidenzino il contributo e il vissuto delle scienziate per inserirli nella narrazione disciplinare, saper riconoscere nelle studentesse e nei rapporti sociali gli stereotipi di genere, progettare azioni didattiche disciplinari e interdisciplinari per far emergere gli stereotipi e per comprenderne l'infondatezza utilizzando un approccio scientifico. Si devono organizzare attività disciplinari e trasversali per far emergere abilità essenziali nella ricerca. Il laboratorio di fisica può essere il luogo giusto in cui far fare esperienze positive alle ragazze per promuovere scelte verso una vita professionale nella scienza.

▲ **Prospects and challenges of a quantum physics cultural education.**
Giliberti M., Lovisetti L.
Physics Department "Aldo Pontremoli" University of Milan, Milan, Italy
Personal culture can be considered as that rich knowledge that make people able of a broad vision, new ideas, and personal reflections about reality. With social culture, instead, we mean those habits, values and behaviours adopted by a given society. But we can also consider disciplinary culture, *i.e.*, the one "identified" by a disciplinarily differentiated group, like physicists. It is from this last point of view that often scientists complain of a lack of diffuse scientific culture. However, scientists themselves rarely ask why, and in what sense, science should really be a cultural part of the whole society. The Physics Education Research Group of the University of Milan strongly believes that such a cultural aspect should be highlighted and placed at the base of physics education. In this talk, we will mainly focus on our work on the historical-philosophical-educational aspects related to the birth of quantum physics, the challenges it generates and the perspectives it opens up for a general overview of the problem. We will discuss motivations, methods, and tools to manifest physics as culturally strongly intertwined with the vision of the world and of life of each of us.

Comunicazioni

● **Nuove sfide e opportunità legate alla digitalizzazione per la didattica della fisica.**
Streit-Bianchi M. ([1]), Bonivento W. ([3]), Michelini M. ([2]), Tuveri M. ([4])
([1]) *INFN, Sezione di Cagliari, Cagliari, Italia*
([2]) *Università di Udine, Udine, Italia*
([3]) *ARSCIENCIA, Vienna, Austria*
([4]) *Università di Cagliari, Cagliari, Italia*
La necessità di stabilire un ponte tra divulgazione, educazione informale e formale in Fisica è alla base del progetto che ha prodotto il libro "Nuove Sfide e Opportunità nella Didattica della Fisica". Applicare le nuove tecnologie digitali in ambito scolastico è spesso una sfida per insegnanti e per alunni. Il libro di cui presenteremo i punti salienti è diviso in due parti: nella prima sono illustrate le attuali ricerche in fisica contemporanea: gravità, fisica quantistica, materia oscura, buchi neri. Storia della fisica, divulgazione, arte e teatro illustrate in quanto proposte divulgative e di educazione informale. La seconda parte è centrata sulla ricerca didattica ed illustra le diverse strategie didattiche sviluppate e/o attuate in vari paesi dall'Italia alla Finlandia, Polonia, Stati Uniti, Vietnam, Australia e Macedonia del Nord nell'utilizzo in classe delle tecnologie digitali. Illustriamo le competenze richieste ai professori dall'utilizzo di queste forme di didattica, le difficoltà dell'apprendimento a distanza ed i programmi disponibili sul web per gli studenti e per gli insegnanti. Science Gateway e e le implicazioni per didattica dell'AI chiudono questa parte.

● **Can Old-Quantum-Theoretical description of physics be rendered coherent? A pilot experimentation for high schools.**
Lovisetti L., Giliberti M.
Physics Department "Aldo Pontremoli", University of Milan, Milan, Italy
Although Old Quantum Theory (OQT) has been internationally part of school curricula and textbooks for years, research made in physics education on OQT is substantially and generally focused on single contents (mainly black-body spectrum, photoelectric effect, and Bohr's atomic model), and not coordinated as a whole framework: therefore, a wide and coherent pedagogical, historical and conceptual presentation is still missing. Is it thus possible to present OQT in a coherent and significant way (without radically changing prerequisites, physics contents, mathematical formalism, and the number of hours usually devoted

to this part)? On this research question, the 15-hour afternoon pilot experimentation "Old (but Gold) Quantum Theory" was designed and tested in early 2023, with 36 high-school students and 9 teachers. Meetings included commented reading of original papers, several groupworks with active understanding, and both qualitative and quantitative examples. Experimentation's effectiveness was evaluated by means of different data: all written groupworks, 5 individual ongoing tests, a satisfaction questionnaire, and a final test with open questions never faced during the course.

L'efficacia delle rappresentazioni matematiche nella comprensione della meccanica quantistica.

Campagnaro S. ([1]), Lovisetti L. ([1]), Porta M. ([2]), Giliberti M. ([1])
([1]) *Dipartimento di Fisica, Università degli Studi di Milano, Milano, Italia*
([2]) *Istituto di Istruzione Superiore "Balbo-Palli", Casale Monferrato, AL, Italia*

La Meccanica Quantistica (MQ) è un argomento di punta nella Ricerca in Didattica della Fisica (RDF). Dalle numerose ricerche in atto, emerge che uno dei maggiori ostacoli all'apprendimento è rappresentato dal contenuto astratto e di difficile visualizzazione della matematica necessaria. Tuttavia, emerge anche che rappresentazioni e visualizzazioni multiple aiutano a superare tale ostacolo; infatti, le varie rappresentazioni non sono didatticamente equivalenti, sia perché ciascuna di esse mette in luce un particolare aspetto dei concetti rappresentati, sia perché esse risuonano in maniera differente a seconda dello studente. Oltre all'approccio algebrico e geometrico con Geogebra, il gruppo di RDF dell'Università degli Studi di Milano ha sviluppato un'applicazione web inedita per la rappresentazione di spazi di Hilbert complessi e/o con più di tre dimensioni, e per la ricerca di autovalori e autovettori di operatori hermitiani. Verrà discussa l'efficacia di tali rappresentazioni, sperimentate presso il Liceo "Palli" (Casale Monferrato, AL) nell'A.S. 2022/23, analizzando i dati derivanti da Moduli Google, questionari in classe, e interviste orali.

Ricercatori per un giorno: la Masterclass di Aria.

Steri A. ([1]), Gabriele F. ([1]), Tuveri M. ([1])([2]), Fadda D. ([3]), Bonivento W. M. ([1])
([1]) *INFN, Sezione di Cagliari, Cagliari, Italia*
([2]) *Dipartimento di Fisica, Università di Cagliari, Cagliari, Italia*
([3]) *Dipartimento di Psicologia, Pedagogia, Filosofia, Università di Cagliari, Cagliari, Italia*

Soddisfare le curiosità degli studenti in merito all'applicazione dei concetti di chimica e fisica affrontati a scuola, spesso percepiti astratti e inutilizzabili nella vita reale e lavorativa, è uno dei compiti del mondo della ricerca. Le attività di didattica informale si muovono in questa direzione: offrono spunti didattici per docenti e studenti e favoriscono la crescita della motivazione e dell'interesse verso la scienza. Da questa esigenza nasce la Masterclass di Aria, condotta all'interno delle attività divulgative del Progetto Aria (INFN) per la ricerca della distillazione criogenica nel campo degli isotopi stabili. Attraverso lo svolgimento di un esercizio contestualizzato e l'apprendimento cooperativo, gli studenti si immedesimano nel ruolo del ricercatore, sfruttano le conoscenze acquisite nel proprio percorso di studi e le applicano per il dimensionamento di una colonna di distillazione. Si discuterà il design dell'attività e la metodologia didattica utilizzata. Si mostreranno i risultati ottenuti attraverso l'implementazione di un opportuno questionario di ricerca in merito alla motivazione e l'interesse sull'attività svolta e i risultati dell'apprendimento.

L'utilizzo di Arduino per lo sviluppo di abilità scientifiche.

Gabelli L. ([1])([2]), Carli M. ([1]), Pantano O. ([1])
([1]) *Dipartimento di Fisica e Astronomia, Università di Padova, Padova, Italia*
([2]) *Istituto Tecnico Industriale "F. Severi", Padova, Italia*

L'utilizzo di Arduino nel laboratorio di fisica nella scuola secondaria di secondo grado può essere una risorsa per realizzare misure sufficientemente precise e proporre un laboratorio a basso costo, senza bisogno di grandi spazi, accessibile a tutti. Oltre a questi benefici pratici ci si chiede se l'utilizzo di Arduino possa essere un'opportunità per lo sviluppo di abilità scientifiche. In questo contributo presentiamo una sperimentazione sulle leggi di Ohm in due classi parallele di un istituto tecnico. In un caso è stato utilizzato Arduino per svolgere l'esperienza di laboratorio, nell'altro caso si utilizzava l'attrezzatura tradizionale a disposizione nel laboratorio. Dall'analisi degli elaborati degli studenti, valutati tramite una rubrica, emerge che i risultati sono comparabili, tranne che nell'abilità di progettazione. Gli studenti che hanno utilizzato Arduino nel fare l'esperienza di laboratorio hanno ricevuto un punteggio mediamente più alto in quest'ambito: hanno deciso in autonomia quali grandezze misurare per rispondere alla propria domanda di indagine e hanno descritto nel dettaglio la procedura prescelta.

Esperimenti di Galileo con Arduino.

Torre M.

Liceo "G. Peano", Tortona, AL

Nell'a.s. 2022-23 in una classe 3 Liceo Scientifico, affrontando il tema della fisica classica e la figura di Galileo Galilei è stato proposto l'analisi di un suo fondamentale esperimento sul moto parabolico e la sua rielaborazione con Arduino. Nel 1607 Galileo in un manoscritto (Folio 116v) riporta risultati sperimentali la cui interpretazione è del massimo interesse: egli suppone che le velocità dei corpi che cadono da una certa altezza sono nello stesso rapporto che le radici quadrate delle distanze percorse. Il dispositivo sperimentale utilizzato da Galileo, e ricostruito in maniera automatizzata con Arduino dagli alunni, era un piano inclinato di 30° posto ad un'altezza di 77,7 cm rispetto al piano di riferimento. Tale altezza consente di avere, per una caduta sul piano inclinato da un'altezza di 28,2 cm, una gittata di 75 cm. I risultati dei tentativi dei lanci sono contrassegnati sul manoscritto da un valore calcolato ("doveria") e da un valore misurato, sintomo inequivocabile che l'sperimento è stato svolto da Galileo. L'analisi di questa fonte originale ha consentito di far rivivere un momento chiave della storia della scienza e della nascita del metodo sperimentale.

"A Glimpse of Light" - An educational proposal for inclusive science teaching.

Dryden E. ([1]), Lippiello S. ([1])([2]), Pantano O. ([1])

([1]) *Dipartimento di Fisica e Astronomia, Università di Padova, Padova, Italia*

([2]) *Liceo Scientifico Statale "Jacopo da Ponte", Bassano del Grappa, VI, Italia*

Despite efforts to increase diversity in STEM fields, gender disparity persists, particularly at the critical point of transition from high school to university. To address this, a project has been designed by the Research Group on Physics and Astronomy Education at the University of Padua to develop and implement orientation actions for high school students, with a focus on improving inclusivity and self-efficacy in STEM. The project involves two 12th-grade groups from a linguistic high school in Italy and consists of a series of activities exploring scientific concepts related to the concept of light while also promoting inclusive learning. The "Design Your Own Problem" assessment tool will be implemented to evaluate the impact of the project by measuring how students integrate their identities into scientific contexts. Moreover, the Physics Self-Efficacy Questionnaire will be used to assess students' confidence in performing Physics-related tasks. By incorporating inclusive and interactive learning practices, this project aims to improve science identity in students and change negative attitudes towards STEM disciplines.

L'uso della matematica in fisica: uno studio attraverso il progetto Virtual School.

Lippiello S. ([1])([2]), Carli M. ([1]), Pantano O. ([1])
([1]) *Dipartimento di Fisica e Astronomia, Università di Padova, Padova, Italia*
([2]) *Liceo Statale "Jacopo da Ponte", Bassano del Grappa, VI, Italia*

Studiare il ruolo della matematica nella fisica può aiutare a capire quali approcci adottano gli studenti nel risolvere problemi di fisica e quali azioni può mettere in atto l'insegnante per supportarli. Una delle maggiori difficoltà consiste infatti nell'uso di strumenti, concetti e metodi matematici in modo significativo in altro contesto, come la fisica. Nell'ambito delle ricerche che il nostro gruppo sta portando avanti sul rapporto tra le due discipline, è stato condotto uno studio sui processi attuati dagli studenti nella risoluzione di problemi di fisica e la loro interpretazione attraverso il riferimento agli *epistemic games* (i modi in cui si inquadra un problema e le mosse per risolverlo). Inoltre è stato implementato il modello di Uhden *et al.* come guida nella progettazione didattica. In questo contributo verrà presentata, in particolare, la sperimentazione fatta in un corso di fisica online per studenti di prima Liceo Scientifico nell'estate 2022 all'interno del programma di ricerca congiunto tra l'Università di Padova e la Monash University in Australia, "Investigating the impact of Virtual School experiences on teaching and learning".

Learning through experience: on the introduction of experimental projects in physics at the University of Calabria.

Pucci G. ([1]), Sposato M. ([2]), Versace C. ([2]), Barberi R.C. ([2])
([1]) *CNR-Nanotec, Rende, CS, Italia*
([2]) *Dipartimento di Fisica, Università della Calabria, Rende,CS, Italia*

In 1975, Yves Couder and his colleagues at Université Paris Diderot started an unconventional class in experimental physics, which today is known as "PhyExp". In PhyExp, groups of students design, build and use a table-top experimental setup trying to answer questions issued by interesting physical phenomena. The questions are proposed by teachers who usually have no experience with the proposed topic and accompany the students in developing their projects. PhyExp is intrinsically non-procedural and thus different from most courses in experimental physics, and it practically introduces the students to an experience of research in physics. At the Department of Physics of the University of Calabria, we have introduced this teaching method within existing classes of experimental physics at both the bachelor and the master levels. Although we were obliged to adapt the method to current temporal and resource constraints, the results regarding student satisfaction and learning opportunity were surprising. I will detail the main features of this method, introduce ideas for student projects, report students' feedback, and discuss how the method could be further implemented and improved.

On the singular behavior of spinning disks and merging black holes.

Conidi F. ([1]), De Luca A. ([1]), Mercuri A. ([1]), Meringolo D. D. ([1]), Sposato M. ([1]), Barberi R. C. ([1]), Pucci G. ([2])
([1]) *Dipartimento di Fisica, Università della Calabria, Rende, CS, Italia*
([2]) *CNR-Nanotec, Rende, CS, Italia e Dipartimento D.I.C.E.A.M., Università degli Studi Mediterranea di Reggio Calabria, Reggio Calabria, Italia*

We highlight the analogy between the signals produced by two disparate physical phenomena: the merging of two orbiting celestial bodies and the spinning of a disk. We develop a low-cost experimental setup for measuring the mechanical vibrations a metallic disk produces by spinning on a plastic sheet. Image analysis allows us to relate the sheet vibration to the disk motion. Similarly to the gravitational signal produced by the astrophysical system,

the sheet vibration is characterized by amplitude and frequency increasing in time, ending with a singular behavior and a ringdown. The simplicity of our experimental setup makes it ideal for illustrative purposes. Finally, a theoretical comparison between the two systems is developed to help understand the origin of the signal analogy.

Studying skylight polarization with a low-cost setup.

Cirimele A. ([1]), Marrella M. ([1]), Zappone B. ([2]), Barberi R. C. ([1]), Pucci G. ([2])
([1]) *Dipartimento di Fisica, Università della Calabria, Rende, CS, Italia*
([2]) *CNR-Nanotec, Rende, CS, Italia*

Lord Rayleigh's explanation of the blue color of the sky is a trope of physics classes to illustrate light scattering by point-like particles. An often overlooked aspect of Rayleigh's theory is that air molecules behave as oscillating dipoles that contribute to the formation of a polarization pattern of the skylight. Indeed, the sky displays a dark bow when observed through a linear polarizer, and interestingly, bees use skylight polarization to orient their flight. As a continuation of an experimental project started during a physics class at the master level, we have developed a simple experimental setup to demonstrate this ubiquitous atmospheric phenomenon. Using two smartphones and a polarizer, we measured the orientation of the dark bow as a function of the position of the Sun at different times of the day, and we characterized the intensity of light with polarization parallel and perpendicular to the ground.

Aula P1 **ore 14:30 – 15:10**

Sezione I
Fisica nucleare e subnucleare
Presiede: Gramegna F. (INFN, Laboratori Nazionali di Legnaro)

Relazione Generale

Fisica ai futuri acceleratori.
Mele B.
INFN, Sezione di Roma, Italia
La programmazione di nuovi acceleratori (oggi in discussione e potenzialmente in funzione dopo il completamento del programma di LHC/HL-LHC) apre scenari di esplorazione del Modello Standard delle interazioni fondamentali e delle sue possibili estensioni con livelli di precisione e/o energia efficace delle collisioni senza precedenti. In questa relazione, saranno riassunti e sottolineati i punti di forza del potenziale di fisica dei vari progetti.

Aula P1 **ore 15:10 – 15:50**

Sezione II
Fisica della materia
Presiede: Cataliotti F.S. (INO-CNR)

Relazione Generale

The physics of thermoresponsive polymer networks: Insights from computer simulations.
Zaccarelli E.
Istituto dei Sistemi Complessi, CNR e Università di Roma La Sapienza
Microgels are soft particles individually made by cross-linked polymer networks which are nowadays widely used as colloidal model systems because of their responsivity to external control parameters. In particular, thermoresponsive microgels undergo a reversible Volume Phase Transition from a swollen to a collapsed state at a given temperature. Recently, we introduced a numerical protocol to synthesize microgels *in silico*, providing a realistic description of the particles in comparison to experiments, and we also put forward a way to numerically calculate their elastic moduli. In addition to microgels, we also investigate hydrogels, *i.e.*, bulk polymer networks. By calculating their elastic properties, we find the emergence of auxetic behavior under tension for hydrogels with a low degree of crosslinking. When the limit of auxeticity is reached (Poisson's ratio $= -1$), a condition that we call "hyper-auxeticity", the mechanical instability triggers the onset of a critical point between two networks of different densities.

Aula P1 **ore 15:50 – 16:30**

Sezione IV
Geofisica e fisica dell'ambiente
Presiedono: Vicari A.M. (INGV)
Madonna F. (Università di Salerno)

Relazione Generale

Cosa sappiamo del passato, presente e futuro climatico del bacino del Mediterraneo.

Coppola E.
Earth System Physics Section, The Abdus Salam International Centre for Theoretical Physics, Trieste

Il bacino del Mediterraneo è considerato un hot spot climatico in quanto ci si aspetta che molteplici condizioni climatiche resposabili di impatti (CID) per la società e l'ecosistema aumentino o diminuiscano all'aumentare del riscaldamento globale. Esaminando accuratamente tutte le molteplici linee di evidenza, è possibile per ognuno di questi indicatori esaminare i trend osservati, stabilire quali dei diversi eventi estremi avvenuti negli ultimi anni possano essere attribuiti al riscaldamento globale e tramite la spiegazione fisica dei meccanismi coinvolti derivare le proiezioni future di questi ultimi a diversi livelli di riscaldamento globale. Inoltre esaminanado il rapporto segnale rumore, è possibile stabilire a quale livello di riscaldamento globale o equivalentemente per quale orizzonte temporale il segnale di cambiamento climatico è superiore alla variabilità naturale climatica per ogni punto della regione del Mediterraneo. Basando l'analisi sulle ultime proiezioni dei modelli globali CMIP6 e regionali CORDEX a diversa risoluzione, si vede come sia molto probabile l'aumento delle ondate di calore e dello stress termico dannoso per la salute delle persone già al superamento della soglia dell'1.5 gradi, così come l'aumento della siccità del suolo che può creare danni all'agricoltura; l'aumento degli eventi estremi di precipitazione in particolare in alcune regioni italiane, alpine e della costa francese e croata; l'aumento della probabilità delle alluvioni fluviali in alcuni tratti della costa adriatica; l'aumento delle condizioni meteorologiche favorevoli agli incendi, l'aumento dell'intensità dei Medicanes nel bacino del Mediterraneo e delle ondate di calore marine. L'incertezza della proiezione di ognuna di queste grandezze varia a seconda della regione, del tipo di indicatore, del livello di riscaldamento globale così come del tipo di modelli esaminati. Raggiungendo scale del chilometro per cui è possibile rappresentare in maniera esplicita il processo della convezione, si rileva una diminuzione di incertezza per intensità, frequenza e precipitazione estrema sia a scala giornaliera ma anche oraria. Tutto questo indica come l'utilizzo della modellistica regionale e dell'aumento della risoluzione sia spaziale che temporale sia necessario per descrivere in maniera più corretta e dettagliata i processi dinamici della piccola scala ma pone l'accento però anche sulla sempre più aumentata richiesta di risorse computazionali e la necessità di utilizzare tecniche alternative di intelligenza artificiale al fine di sopperire a questa richiesta.

Aula F1 - Augusta Manfredini **ore 09:00 – 13:30**

Sezione I

Fisica nucleare e subnucleare

Presiede: Di Ciaccio A. (INFN, Sezione di Roma 2)

Relazioni su invito

▲ **Risultati recenti e prospettive future a Belle II.**

Casarosa G. per la Belle II Collaboration

Dipartimento di Fisica, Università di Pisa e INFN, Sezione di Pisa

L'esperimento Belle II alla SuperB-Factory SuperKEK-B ha raccolto 424 fb^{-1} dall'inizio della presa dati nel 2019, dimostrando eccellenti prestazioni di ricostruzione. Queste hanno permesso di produrre recentemente diverse misure significative in ricerche di fisica oltre il Modello Standard nella fisica dei quark, dei leptoni tau, e della materia oscura a bassa massa —molte delle quali unicamente accessibili a Belle II. In questa comunicazione si discuteranno i risultati più rilevanti ed il loro impatto con qualche cenno alle prospettive sul potenziale futuro dell'esperimento.

▲ **Progresses with FCC.**

Gaudio G.

INFN, Sezione di Pavia

The European Strategy for particle physics recommended the development of a circular hadron collider, preceded by an electron-positron collider. Those accelerators will push the frontier of precision measurements in particle physics to unprecedented levels. This will allow for constraints of precision observables of the Standard Model and opens up possibility to spot new physics from either direct searches or discrepancies in the Standard Model predictions. In the last years a lot of progress has been achieved in several aspects of the feasibility of the projects, including progress in the detector and physics studies. In this communication the current status of both the accelerator and the experiment will be reviewed, with particular focus on the FCC-ee accelerator.

Comunicazioni

● **Ricerca di eventi di produzione di coppie di bosoni di Higgs con l'esperimento CMS.**

D'Anzi B.

Università di Bari e INFN, Sezione di Bari

Un obiettivo fondamentale della ricerca in fisica delle alte energie è quello di far luce sulla realtà del meccanismo di Higgs attraverso lo studio del potenziale di Higgs. Infatti un test importante del Modello standard è la determinazione della forma del potenziale di Higgs e degli accoppiamenti del campo di Higgs con se stesso. L'accoppiamento trilineare può essere estratto dalle misure relative alla produzione non risonante di coppie di bosoni di Higgs. In questa comunicazione vengono presentati i risultati più recenti delle analisi per la ricerca di eventi di doppio Higgs in numerosi canali di decadimento e la loro combinazione utilizzando i dati acquisiti con l'esperimento CMS durante il Run2.

Phenomenology at the LHC of composite boson leptoquarks from strongly interacting standard model fermions via four-fermion operators of NJL type.
Ajmal S. ([1])([2]), Panella O. ([2]), Presilla M. ([2]), Romeo F. ([3]), Gaglione T.J. ([3]), Xue S.S. ([2])([5])([6]), Sun H. ([4]), Gurrola G. ([3]), Leonardi R. ([2])
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Four-fermion operators of the Nambu–Jona-Lasinio (NJL) type have a strong coupling UV fixed point at TeV scale, where two SM elementary fermions form a bound state of composite boson leptoquark (LQ) and they couple to their constituents via effective contact interactions at composite scale $\Lambda \approx \mathcal{O}$ TeV. We present a phenomenological analysis to explore LQs at LHC by computing the production cross-sections of LQs in the context of relevant experiments at the LHC with *pp* and *ap* collision. In *ap* collision, photons can be elastic or inelastic. Also, there could be a possibility of producing leptons from protons, it is possible to target these processes at the LHC as well. We have made a comparison of LQ's production with the above-mentioned mechanisms. For sensitivity studies, we produced signals for the first two generation LQs via Madgraph. Parton showering and detector simulations are being implemented via pythia8 and Delphes. The region of parameter space is explored where this composite LQ can appear using different choices of luminosity, also expected by the High-Luminosity LHC, computing 3 and 5σ contour plots of its statistical significance.

Study of the impact of unitarity bounds on analysis of Vector Boson Scattering with same-sign W processes at LHC.
Carrivale C. ([1]), Ajmal S. ([1]), Panella O. ([2]), Presilla M. ([2])
([1]) *Dipartimento di Fisica e Geologia, Università degli Studi di Perugia, Italia*
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Effective Field Theories (EFT) are a powerful instrument for researching the effects of Beyond Standard Model (BSM) physics. The introduction of EFT contributions could lead to an unphysical growth of scattering amplitudes and then to a violation of unitarity above a particular value of the center-of-mass energy. To validate the EFT approach in this region is necessary to implement unitarity constraints. The object of this communication is a study of Vector Boson Scattering processes with same-sign W bosons in the context of SM EFT. The analysis is performed at the generator level on Monte Carlo samples at a luminosity of 138 inverse fb, corresponding to the data collected during Run II of the LHC. The kinematic constraints necessary to restore the physical sense of the approach in high-energy regions are determined as a function of Wilson coefficients of relevant dimension-six and dimension-eight operators, and the impact of the unitarity constraints on the observables is quantified via a likelihood-based approach. Finally, the consequences of the obtained results are discussed.

Prospects for measuring A_{FB}^{b} at the ATLAS Experiment at the LHC and at the FCC-ee.
Toffolin L.
Dipartimento di Fisica, Università degli Studi di Trieste, Italia e INFN, Sezione di Trieste, Gruppo Collegato di Udine, Italia
In the electroweak sector of the Standard Model, the two most sensitive determinations of $\sin^2\theta_{W,eff}$, from the LEP measurement of the b forward-backward asymmetry at the Z-boson

pole, A_{FB}^b, and the SLD measurement of the parameter A_ℓ, are in $\sim 3\sigma$ tension with each other, the largest deviation in global electroweak fits. To shed light on this discrepancy in the SM, a new experimental determination of A_{FB}^b is quite urgent. I discuss the measurement of A_{FB}^b at the LHC. I consider the process $pp \to Zb$, with $Z \to e^+e^-$, $\mu^+\mu^-$, explaining the possibility of identifying the b-jet charge using either constituent tracks information or exploiting the charge of soft muons from B-hadron decays. I present preliminary studies based on simulated events and part of the LHC Run-2 and Run-3 datasets collected by the ATLAS Experiment, which show that a measurement competitive with LEP is in reach. I also present a feasibility study on the A_{FB}^b measurement in the production of a $b\bar{b}$ pair from a decaying Z-boson at the FCC-ee, with a Delphes-based simulation tuned to the FCC-ee parameters.

Misura della violazione di CP nel decadimento di $B_s \to J/\psi\phi$ in CMS.

Lusiani E.

INFN, Sezione di Padova

La violazione CP nel sistema dei mesoni B_s–anti-B_s è caratterizzata dalla fase ϕ_s. Discrepanze tra predizione e misura di questo parametro possono indicare la presenza di nuova fisica oltre lo Standard Model. Il parametro ϕ_s è ben stimato nello Standard Model, con un'incertezza teorica dell'ordine del millirad da compararsi con la media mondiale con un'incertezza di circa 19 millirad. Nella comunicazione verranno mostrati i più recenti risultati raggiunti da CMS in questo ambito, ottenuti tramite un'analisi angolare del decadimento $B_s \to J/\psi(\mu^+\mu^-)\phi(K^+K^-)$ per separare gli autostati di CP, consentendo inoltre di determinare la loro differenza di larghezza e di massa. L'analisi necessita di stime del flavor di produzione del mesone di segnale, e fa uso di diversi flavor tagger basati su decadimenti del secondo mesone B prodotto nell'evento e di uno basato sull'adronizzazione del mesone di segnale stesso. Grazie all'ottima performance di questi nuovi algoritmi, la misura ha migliorato notevolmente la precisione rispetto a precedenti misure degli stessi parametri in CMS.

Search for Higgs boson pair production via gluon-gluon Fusion and Vector Boson Fusion in the $b\bar{b}\gamma\gamma$ final state from 13 TeV pp collisions data with the ATLAS detector.

Mazzeo E.

Università degli Studi di Milano e INFN, Sezione di Milano

A search for di-Higgs boson production in the $b\bar{b}\gamma\gamma$ final state is presented, using data collected by the ATLAS experiment during the second data-taking period (Run 2) of the LHC, amounting to an integrated luminosity of 140 fb^{-1}. Searching for Higgs boson pairs provides an excellent handle for understanding the fundamentals of the Higgs mechanism, and in particular for measuring the trilinear Higgs boson self-coupling λ_{HHH}, which is still largely unconstrained. In the new $HH \to b\bar{b}\gamma\gamma$ analysis discussed here the two dominant HH production modes (via gluon-gluon Fusion and Vector Boson Fusion) are probed, thus enhancing the sensitivity to λ_{HHH}. Moreover, the Vector Boson Fusion production mode constitutes a unique probe to the quartic interaction between two vector bosons and two Higgs bosons (namely, $HHVV$). In case no excess with respect to background expectations is found, upper limits on the di-Higgs production cross-section are placed, and exclusion intervals on the Higgs self-coupling λ_{HHH} and the strength of the $HHVV$ interaction are set.

Dual-Readout calorimeter prototype for future HEP experiments.

Pareti A.

Dipartimento di Fisica, Università degli Studi di Pavia, Italia

The next generation of Particle Physics experiments, aiming at precise measurements of the Higgs boson, will require a drastically improved resolution on hadronic jet energies with respect to existing collider detectors. The HiDRa (High-Resolution Highly Granular Dual-Readout Demonstrator) calorimeter prototype exploits Dual-Readout techniques to improve the energy resolution, with particular focus on hadronic jets. Its fibre-based design also allows detailed spatial reconstruction and particle identification through independent SiPM readout. In this communication I will review the physics goals behind the design of Dual-Readout calorimeters. As part of the development team, I have realized Geant4 simulation-based performance studies for the HiDRa prototype and for the parameter optimization of a full-containing hadronic shower calorimeter. I will compare the results with next-generation HEP experiment benchmarks. Finally, I will describe the next steps in the study, consisting of Machine Learning applications to take full advantage of the high-granularity design of fiber-based Dual-Readout calorimeters.

Measurement of signal propagation in RPC readout panels for ATLAS phase 2 upgrade.

Passarelli D. ([1]), Carducci G. ([1])([2]), Falsetti G. ([1])([2]), Schioppa M. ([1])([2])

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The major phase 2 upgrade of the ATLAS Muon Spectrometer involves the installation of a trigger station in the innermost part of the barrel. The trigger chambers are a new generation of RPCs with 1 mm separation between 1.4 mm thick resistive electrodes. In planar electrode detectors the gain grows exponentially with the distance traveled by the electrons in the amplification gap, so as the thickness of the gap is only 1 mm, the average charge signal that is produced is much smaller than in traditional RPCs from 2 mm gas gap. Consequently, the signal induced on the strips facing the gas gap is much smaller. This entails the need to integrally transport the induced signal to the first amplification stage of the front-end electronics. This communication focuses on the measurement of the signal propagation along the reading strips of these 1 mm gas gap RPCs with and without a metal perimeter frame inside the strip panels. The signal simulation in this type of RPC is also presented. The simulated characteristic impedance and crosstalk were compared to the measured value to validate this model. This method is applied to several RPC design geometries, including the proposed new reading scheme.

The mechanical structure of the drift chamber for the IDEA experiment at FCC-ee.

Procacci F.M.

Dipartimento di Fisica, Università degli Studi di Bari, Italia e Dipartimento di Meccanica, Matematica e Management, Politecnico di Bari, Italia

IDEA (Innovative Detector for an Electron-positron Accelerator) is a general-purpose detector concept, designed to study electron-positron collisions in a wide energy range in a very large circular leptonic collider. Its drift chamber is designed to provide an efficient tracking, a high precision momentum measurement and an excellent particle identification. The construction of IDEA drift chamber is driven by two main purposes: to maximize the transparency in terms of radiation length and mechanical stability, that means reducing the deformations of the end plates under the total load of the wires to acceptable limits. About the first item, a significant reduction in the amount of material at the end plates could be

obtained by separating the gas containment function from the wire tension support function. Thereby anchoring the wires to a self-sustaining light structure, named "wire-cage", and surrounding this structure with a thin skin of suitable profile, the gas differential pressure with respect to the outside is compensated. This contribution analyzes the details of the chamber, the complete mechanical design of the wire-cage and the simulations about the mechanical stability.

Performance of the CMS tracker during Run 3 data taking.

Roy Chowdhury S.
Università di Pisa e INFN, Sezione di Pisa

The CMS inner tracking system consists of silicon pixel and silicon strip detectors. The tracker is designed to measure the trajectory of the charged particles tracks. The pixel detector provided high-quality physics data during the LHC Run 2, finishing with a detector live fraction of 95% and hit efficiency of $> 99\%$ in all but the innermost layer. After the end of Run 2 in 2018, a thorough refurbishment of the detector was done including the replacement of the innermost barrel layer. The refurbished pixel detector was reinstalled in CMS in June 2021, followed by an extensive commissioning period. The CMS silicon strip tracker has been successfully taking data in LHC Run 1 and Run 2. After the second long shutdown period from the end of 2018, the detector resumed operations in summer 2021. Since last year, both the CMS pixel and strip detectors have been successfully taking data at 13.6 TeV collisions. In this communication, the performance of the CMS pixel and silicon strip detector during the Run 3 operation will be summarized. In addition, results of the complex tracker alignment procedure will be highlighted.

Search for intrinsic charm in the ATLAS experiment using multivariate techniques.

Boccardo L.
Università di Genova, Italia e INFN, Sezione di Genova, Italia

This work aims at researching intrinsic charm in proton-proton collisions at 13 TeV in the ATLAS experiment. In particular, the final state with a Z vector boson produced in association with heavy flavored jets will be discussed. In addition, the approach to PDF fitting that allowed NNPDF to observe intrinsic charm will be analyzed through symbolic regression techniques. Symbolic regression is used to approximate a neural network with a corresponding functional form. This technique will be applied to the NNPDF set in order to extract its functional form.

Measurement of charm mixing and CP violation parameter.

Anelli A.
Dipartimento di Fisica, Università degli Studi Milano Bicocca, Italia e INFN, Sezione di Milano Bicocca, Italia

The recent discovery of CP violation in D^0 mesons by the LHCb experiment raised theoretical and experimental interest. It is still unclear whether this result is compatible with the Standard Model and there is a general consensus on the need of further measurements to clarify the picture. The LHCb experiment is therefore conducting a wide range of searches for CP violation in charm using multiple observables. Among those, y_{CP} is sensible to CP violation in the mixing of D^0 mesons and is sensible to beyond the Standard Model effects. By measuring the difference of the effective decay widths of D^0 and its antiparticle, any deviation from the known mixing observable y would provide indication of CP violation. This communication will show the latest measurements of y_{CP} from LHCb as well as prospects of the LHCb Upgrade and the Run3 of LHC.

Measurement of differential distribution of $B_s \to D_s^* \mu \nu_\mu$ at LHCb.

Manganella F.

Dipartimento di Fisica, Università di Roma La Sapienza, Italy e INFN, Sezione di Roma, Italy

Semileptonic decays of the B_s meson play a crucial role in the validation of the Standard Model. They are helpful to constrain the parameters of the CKM matrix, to test the Lepton Flavour Universality, to understand the CP violation and to investigate New Physics effects. The analysis presented here aims to a complete the study of the decay kinematics of the semileptonic decay $B_s \to D_s^* \mu \nu_\mu$, with $D_s^* \to D_s \gamma$, using data collected by LHCb in Run 2. The decay considered can be fully described by four variables: the invariant mass squared q^2 of the lepton pairs and three decay angles, θ_l, θ_d and χ, reconstructed from the particles in the final state and the initial B_s flight direction. The full differential distribution in these four kinematic variables is produced, taking into account the detector acceptance, as well as the reconstructed efficiencies and the resolution effects. Then, a fit to this differential distribution is performed using different parametrisations for the $B_s \to D_s^*$ transition form factors and various kind of New Physics contributions.

Risultati recenti sulle ricerche di segnali nel settore oscuro a Belle II.

Martellini C.

Istituto Nazionale di Fisica Nucleare, INFN, Sezione di Roma Tre e Università degli Studi Niccolò Cusano, Dipartimento di Ingegneria

L'esperimento Belle II installato alla SuperB-Factory SuperKEK-B ha raccolto 424 fb^{-}1 dall'inizio della presa dati nel 2019. Belle II ha una sensibilità unica a segnali di nuova fisica previsti da un'ampia classe di modelli che postulano l'esistenza di particelle di materia oscura. In questa relazione si presentano i più recenti risultati delle ricerche di Belle II nel settore oscuro, che includono anche limiti sul bosone Z' e l'Higgs oscuro, e le prospettive a breve termine per ulteriori ricerche in questo campo.

Aula F8 - Maria Marinaro **ore 09:00 – 13:30**

Sezione II
Fisica della materia
Presiede: Caviglia A. (Università di Ginevra)

Relazioni su invito

▲ **Optomechanical coupling of orbital angular momentum with membranes.**
Parisi M. ([1]), Marino A. ([2]), Borrielli A. ([3]), Bonaldi M. ([3]), Piccirillo B. ([4]), Paparo D. ([5]), Rubano A. ([4]), Mosca S. ([1])
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([2]) *CNR-ISASI, Institute of Applied Sciences and Intelligent Systems "E. Caianiello", c/o Physics Department, University of Naples Federico II, Naples, Italy*
([3]) *CNR-IMEM, Institute of Materials for Electronics and Magnetism, FBK Trento Unit, Trento, Italy*
([4]) *Physics Department, University of Naples Federico II, Napoli, Italy*
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Optomechanical linear momentum coupling has been demonstrated in classical and quantum regime and in pioneering Beth's experiment the spin part of the photon angular momentum was involved in the manipulation of macroscopic objects. However, Allen *et al.* in 1992 pointed out the possibility to also transfer orbital angular momentum (OAM) of light to matter. The OAM, unlike spin, can in principle take unlimited values making it attractive in the communication field to potentiality transfer a wealth of information between different nodes of a network. Recently, torsional oscillators have been used to couple and detect optical OAM and optomechanically induced transparency phenomenon in a rotational-cavity have been investigated and proposed for the OAM detection. Here, we propose to exploit optomechanical coupling by using an ultra-low dissipation mechanical silicon nitride membrane, to realize a transducer of orbital angular momentum of light. We couple OAM from optical to mechanical domain by the coupling between a Hermite-Gauss beam (1,1) and the first normal mode of the membranes.

▲ **Voltage-driven control of superconducting currents.**
Di Bernardo A. ([1])([2]), Ruf L. ([1]), Koch J. ([1]), Cirillo C. ([3]), Puglia C. ([4]), Puliyappara-Babu P. ([1]), Hartmann R. ([1]), Vecchione A. ([3]), Belzig W. ([1]), Giazotto F. ([4]), Attanasio C. ([2]), Scheer E. ([1])
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([4]) *NEST Laboratory, Istituto Nanoscienze and Scuola Normale Superiore, Pisa, Italy*
In conventional metal-oxide semiconductor (CMOS) electronics, the logic state of a device is set by a gate voltage (V_g). The superconducting equivalent of such effect had remained unknown until it was recently shown that a V_g can tune the superconducting current (supercurrent) flowing through a nanoconstriction in a superconductor. This so-called gate-controlled supercurrent (GCS) effect has raised great interest because it can lead to superconducting logics like CMOS logics, but with lower energy dissipation. In this talk, I will review the

different mechanisms that have been proposed to explain the GCS effect, and present results obtained from our group which demonstrate evidence for the same effect. I will discuss the importance of physical parameters like spin-orbit coupling, disorder, and surface states for the observation of the GCS effect, starting from a series of experiments that we have systematically carried out on a variety of gate-controlled devices based on elemental metallic superconductors (*e.g.*, Nb), non-centrosymmetric superconductors (*e.g.*, $Nb_{0.18}Re_{0.82}$) and unconventional oxide superconductors (Sr_2RuO_4) and fabricated via different approaches.

Comunicazioni

The role of intrinsic defects and surface adsorbates on photoresponse in monolayer MoS_2 transistors.

Durante O. ([1])([2]), Kumar A. ([1]), Sessa A. ([1]), Faella E. ([1])([2]), Viscardi L. ([1])([2]), Intonti K. ([1])([2]), Giubileo F. ([2]), Martucciello N. ([2]), Romano P. ([3]), Sleziona S. ([4]), Schleberger M. ([4])([1]), Di Bartolomeo A. ([1])([2])

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Owing to its strong light absorption and excellent mechanical properties, monolayer molybdenum disulfide (MoS_2) has been identified as an ideal material for ultrathin and flexible photodetectors. However, the photoresponse of monolayer MoS_2 can be difficult to interpret and requires great attention. In this work, the photoconductivity of back-gate monolayer MoS_2 transistors has been studied as a function of temperature and pressure. It has been shown that the time-resolved photocurrent behaviour is dominated by faster photobolometric and slower photogating effects that are attributed to charge trapping/detrapping by shallow and deeper intragap states as well as to desorption of polar adsorbates. Moreover, the temperature dependence of photoconductivity can be explained by photo-induced desorption of adsorbates, such as O_2 and H_2O molecules, that enhance the n-doping level of the MoS_2 channel. Then, this study aims to clarify how intrinsic defects and adsorbates on the surface of MoS_2 play a key role in the temperature behaviour of the time-resolved photoresponse of the material.

Investigating the influence of oxygen vacancies on the performance of sputtered gadolinium-doped ceria thin films in solid oxide fuel cells via X-ray photoelectron spectroscopy and in-operando X-ray absorption spectroscopy.

Ur Rehman H.S., Coppola N., Carapella G., Braglia L., Montinaro D., Torelli P., Maritato L., Aruta C., Galdi A.

University of Salerno

In recent years, gadolinium-doped ceria (GDC) barrier layers have been reported to enhance the performance of solid oxide fuel cells (SOFCs) by reducing cathode/electrolyte interface diffusion and improving ionic conductivity. Previous studies showed that a room-temperature–sputtered GDC thin film can significantly increase output current (+78%) and decrease ohmic resistance (up to −42%) in SOFCs compared to screen-printed industrial SOFCs. The enhanced performance is attributed to the decreased grain size of the GDC layer at a lower annealing temperature. However, the density and activity of oxygen vacancies in the thin film remain unknown. To understand the interplay between morphology and stoichiometry in determining the Ce^{3+}/Ce^{4+} ratio that governs ionic and electronic conductivity, quantitative XPS and XAS were used to investigate the atomic-level characterization of GDC layers. This study focused on three RF-sputtered GDC thin films, which were annealed at different plateau temperatures. Results revealed that annealing parameters played

a role in the number of available oxygen vacancies in the oxygen-reduction reaction (ORR), inducing different changes in the investigated samples.

TR-ARPES signal in germanium pumped with an ultrashort IR pulse.
Avella A., Eskandari-asl A.
Università degli Studi di Salerno, CNR-SPIN, CNISM
Recent advances in technology made it possible to study the ultra-fast charge dynamics in pumped systems, which calls for advanced theoretical approaches to simulate experiments in an efficient way. Recently, we have applied our newly developed theoretical method, the Dynamical Projective Operatorial Approach (DPOA), to simulate the ultra-fast charge excitation dynamics recently measured in germanium and benchmarked our results with TD-DFT ones. In this work, we use our theory to compute the TR-ARPES signal and its out-of-equilibrium spectra of a germanium sample pumped with an ultra-short IR pulse and study its behavior for different probe parameters. Studying the dynamical and residual signals, we clarify how the pump affects the dynamical energy bands and induces different types of transient sidebands in the system and shed some light on the electron dynamics in the system as well as on the residual charge excitations.

Impact of pressure on the photoresponse of ReS_2-based field effect transistors.
Intonti K. ([1])([2]), Faella E. ([1])([2]), Kumar A. ([1]), Viscardi L. ([1])([2]), Giubileo F. ([2]), Lam H.T. ([3]), Anastasiou K. ([3]), Craciun M. ([3]), Russo S. ([3]), Di Bartolomeo A. ([1])([2])
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In this study, field effect transistors with few-layer ReS_2-based channel were electrically and optically characterized at various pressures. The devices show n-type behaviour and the linear output characteristics reveal low Schottky barriers between the Cr/Au metal contacts and the ReS_2 flake. By lowering pressure from 10^3 mbar to 1.8 mbar first and then to 2×10^{-4} mbar, there is an increase in conductivity, and a reduction in the I_{on}/I_{off} ratio. This is because electronegative air molecules desorb from the ReS_2 surface, making the n-type electron doping of the material increase. Under a white-supercontinuum laser illumination, the device exhibits positive photoconductivity, but with different properties depending on the applied pressure. Persistent photoconductivity is observed at ambient pressure and has an impact on the photocurrent dependence on the laser intensity. At 1.8 mbar the photocurrent follows a linear low as a function of the laser power and slightly increases with the laser exposure time. At high vacuum, instead, when persistent photoconductivity no longer occurs, a significant increase in the photocurrent with illumination time is seen.

Ab initio overestimation of the topological region in Eu-based compounds.
Autieri C.
International Research Centre Magtop, Institute of Physics, Polish Academy of Sciences, Warsaw, Poland
An overestimation of the fundamental band gap values by the density functional theory within the local density approximation and associated approaches is a well-known challenge of *ab initio* electronic structure computations. Motivated by recent optical experiments, we have revisited first-principle results obtained earlier for $EuCd_2As_2$ and extended the computations to the whole class of systems $EuCd_2X_2$ (X = P, As, Sb, Bi), to $EuIn_2X_2$ (X = P, As, Sb) and to the Eu-free $AEIn_2As_2$ (AE = Ca, Sr, Ba) employing a hybrid functional

method. We find that our approach provides the magnitude of the energy gap for $EuCd_2As_2$ in agreement with the experimental value. Actually, our results indicate that $EuCd_2Bi_2$ and $BaIn_2As_2$ are robust topological insulators, while all other compounds are topologically trivial semiconductors. The Eu-based systems are AFM semiconductors with a strong red shift of the energy gap in a magnetic field caused by the exchange coupling of the band states to spins localized on the $4f$-shell of Eu ions. Additionally, the $EuIn_2X_2$ (X = P, As) compounds show altermagnetism.

Nanostructure phase selection in vacuum-grown Ni-TPP thin films.

Pancaldi A., Raimondo L., Minotto A., Sassella A.

Dipartimento di Scienza dei Materiali, Università degli Studi di Milano-Bicocca, Italia

The control on the growth of organic semiconductor thin films is one of the most intriguing challenges in the field of organic electronics, in view of understanding film properties and taking advantage of them in devices. Much effort has been devoted to the comprehension of the growth mechanisms, highly dependent on the growth technique and conditions employed, in view of obtaining samples with the desired morphology and properties. Among organic semiconductors, tetraphenylporphyrins (TPPs) are chosen for their great potential in many technological fields, such as gas sensing, energy capture and transfer. Here, we present a comparative study of nickel-TPP thin films deposited, by means of organic molecular beam epitaxy, onto potassium acid phthalate (KAP) crystalline substrates following different growth protocols. The monitoring of film morphology performed *ex situ* by atomic force microscopy reveals the formation of nanoaggregates, in most cases accompanied by an evolution of the island structure from amorphous to crystalline. By properly adjusting the growth parameters, one single stable phase can be selected and its structure and properties studied.

Tight-binding matrices of graphene nanocones: Spectral properties and combinatorics.

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Physics often entails beautiful mathematics, and graphene nanocones are no exception. In this paper, the tight-binding matrices of honeycomb triangles and trapezia are investigated, and intriguing mathematical features of their determinants are uncovered. In particular, three identities for the Hückel determinant are conjectured, involving permanents and Pascal matrices, or variants of them, with binomial coefficients as their elements. This establishes connections with counting problems in statistical mechanics and has implications in theoretical chemistry.

Optoelectronic properties of mechanically exfoliated two-dimensional α-In_2Se_3 field effect transistor.

Pelella A. ([1]), Intonti K. ([2]), Viscardi L. ([2]), Durante O. ([2]), Capista D. ([3]), Passacantando M. ([3]), Giubileo F. ([5]), Alshehri M.A.S. ([4]), Alghamdi M.S.G. ([4]), Craciun M. ([4]), Russo S. ([4]), Di Bartolomeo A. ([2])

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Mechanically exfoliated two-dimensional α-In_2Se_3 flakes are used as channel for field effect transistors. Good carriers' mobility and low subthreshold swing have been demonstrated, making such a device suitable for a wide range of applications, from digital logic to memory applications. Moreover, the device can work as a photodetector, generating a photocurrent when illuminated by laser with wavelengths from visible to infrared region. Besides the wide-spectrum response, a responsivity up to 1.3 kA/W is reached at low power with few hundred milliseconds as time responses.

Bi-based topological insulators grown by optical floating zone technique.
Guarino A. ([1]), Arumugam R. ([1]), Fittipaldi R ([1]), Lettieri M ([1]), Balakrishnan G ([2]), Vecchione A ([1])
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During the last decade, bismuth chalcogenides have been largely investigated due to their applications as functional thermoelectric materials but also for their intriguing topological properties. For studying equilibrium and out-of-equilibrium properties of low bandgap samples an efficient growth method is needed to obtain pure samples with on-demand band gap. In this study, optical floating zone technique has been used to grow high-quality single crystals of pure Bi_2Se_3 and Bi_2Te_3 as well as crystals with optimum concentrations of Sb and/or Te to improve the electrical properties and/or to increase the band gap amplitude of the compounds aiming to explore nonlinear properties of solids by high-order harmonic generation spectroscopy. Systematic structural, morphological, and compositional characterizations have been performed on the different sets of grown samples to investigate the quality of the crystals. Preliminary electrical transport measurements have been performed to check their charge carrier mobility.

2D p-type black phosphorus for optoelectronic devices.
Kumar A. ([1]), Viscardi L. ([1])([2]), Faella E. ([1])([2]), Intonti K. ([1])([2]), Durante O. ([1])([2]), Giubileo F. ([2]), Palella A. ([3]), Sleziona S. ([4]), Schleberger M. ([4]), Di Bartolomeo A. ([1])([2])
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([4]) *Fakultät für Physik and CENIDE, Universität Duisburg-Essen, Duisburg, Germany*
Few-layered black phosphorus has shown significant potential, due to its ultrathin layered structure, high carrier mobility, mechanical flexibility, and thickness-dependent direct band gap. Herein, we will be presenting the latest results obtained on the fabricated device based on a thin layer BP channel. The fabricated device exhibits unipolar p-type transport with high hole mobility at low Vds. The device shows a linear increase in photocurrent as a function of incident laser power and exposure duration. The results confirm high photoresponsivity from the device under white light illumination. Further, a long photocurrent decay time characteristic confirms the single type of traps dominating the process. Moreover, the temperature-dependent transport measurements show that electrical conductance and field-effect mobility decrease with increasing temperature. The transfer curves show an increase in the hysteresis width and thus can be exploited to enable non-volatile memories with a wider programming window at higher temperatures. The obtained results are significant and can be of interest to the researchers involved in the 2D materials for potential optoelectronic applications.

Electric transport properties in few-layers WTe_2 field-effect transistor.
Faella E. (1)(2), Viscardi L. (1)(2), Alghamdi M.S.G. (3), Alshehri M.A.S. (3), Ogrin F. (4)(5), Lamberti P. (6), Craciun M. (3), Russo S. (3), Di Bartolomeo A. (1)(2)
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(3) *Centre for Graphene Science, University of Exeter, UK*
(4) *School of Physics and Engineering, University of Exeter, UK*
(5) *MaxLLG Ltd., Exeter, UK*
(6) *Dipartimento di Dipartimento di Ingegneria dell'Informazione ed Elettrica e Matematica Applicata, Università degli Studi di Salerno, Italia*
Two-dimensional (2D) materials have attracted great interest in recent decades. Their electrical and optoelectronic properties make them promising candidates for next-generation devices. These materials are usually produced by exfoliation or chemical vapour deposition (CVD). 2D tungsten chalcogenides possess fascinating properties due to their layered structure held together by weak van der Waals forces. They have a strong spin-orbit interaction, which makes them suitable for use in spintronics and valleytronics. Here we present tungsten ditellurium (WTe_2), a semimetal that has an extremely large magnetoresistance. Additionally, it can undergo ferroelectric switching in the 2D form, and possesses topological electronic states that make it an extremely versatile material. We report a study of the electrical transport properties of field-effect transistors (FETs) with the WTe_2 channel. The WTe_2 flakes are mechanically exfoliated, and different metals are selected for the source and drain electrodes. We investigate the dependence of the electrical properties on the flake thickness, air pressure and temperature in the wide range from 77 to 410 K.

Non-linear and anomalous planar Hall effects in quantum materials.
Ortix C.
Dipartimento di Fisica, Università di Salerno
It has been recently established that Hall transverse currents can appear as a second-order response to electric fields. This non-linear Hall effect possesses a quantum part from the Berry curvature dipole, and has been observed in two-dimensional materials with strong spin-orbit coupling. In this talk I will show that this geometric effect can appear in the complete absence of spin-orbit coupling. In these systems, crystalline anisotropies can trigger sizeable Berry curvature dipoles. I will show that uniaxially strained bilayer graphene and oxide heterostructures display this effect. I will also show that the Berry curvature in trigonal crystals can yield an anomalous planar Hall effect producing a transverse current even in a configuration where the driving electric field is aligned with the external magnetic field.

Electric transport and low-frequency noise characterization of Bi_2Se_3 topological insulator thin films.
Barone C. (1)(2)(3), Orgiani P. (4), Carapella G. (1)(2)(3), Granata V. (1)(3), Chaluvadi S.K. (4), Pagano S. (1)(2)(3)
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(2) *CNR-SPIN, c/o Università degli Studi di Salerno, Fisciano, Salerno, Italy*
(3) *INFN Gruppo Collegato di Salerno, c/o Università degli Studi di Salerno, Fisciano, Salerno, Italy*
(4) *Istituto Officina dei Materiali, IOM - CNR, Area Science Park, Trieste, Italy*
New states of quantum matter, not directly related to conventional insulators and semiconductors, are represented by topological insulators. Due to a strong contribution of the surface to transport, these compounds have attracted an increasing interest. In order to

better investigate the effect of intrinsic fluctuations on the surface conduction, a detailed characterization of the low-frequency noise has been made on Bi_2Se_3 thin films. The experiments have been performed by varying the samples thickness and geometry, in a temperature range from 300 down to 8 K, and as a function of dc bias current and gate voltage. The obtained results have shown standard thermal and shot noise contributions, while an unusual reduction of the $1/f$ noise component has been found. This behavior, especially evident in the low-temperature region, has been correlated with structural and dc electric transport properties. From the observations reported, a clear indication on the occurrence of the topological regime has been observed. Therefore, flicker noise measurement is a valid alternative technique to standard topological surface state spectroscopy.

Strain effects in MoS_2 monolayer: A scanning probe microscopy study.

Di Giorgio C. ([1])([2])([3]), Blundo E. ([4]), Basset J. ([2]), Pettinari G. ([5]), Felici M. ([4]), Polimeni A. ([4]), Aprili M. ([2]), Bobba F. ([1])

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Number of monolayers (MLs), strain, inter-layer twist angle, charge transfer, and hydrostatic pressure can be used as additional degrees of freedom to tune the physical properties of semiconducting transition metal dichalcogenides. Among the others, molybdenum disulfide (MoS_2) deserves a special attention, given the high tunability of both its opto-electronic and elasto-mechanical properties depending on the material engineering. Here, we will discuss the change induced in MLs of MoS_2, by engineering the strain configuration. By using scanning probe microscopy techniques, such as electrostatic force, Kelvin probe and scanning tunneling microscopy, we will demonstrate that the charge carrier density, the defective state and, ultimately, the density of states of MoS_2 MLs are highly sensitive to strain.

Study of two-dimensional materials and thin films using X-rays.

Vasi S. ([1]), Ceccio G. ([2]), Wanderlingh U. ([1])

([1]) *Dipartimento di Scienze Matematiche e Informatiche, Scienze Fisiche e Scienze della Terra, Università degli Studi di Messina, Italia*

([2]) *Nuclear Physics Institute, NPI, of CAS, Rez, Czech Republic*

Innovative materials, such as ultra-thin films or 2-dimensional compounds, are extremely interesting and are being studied especially for possible applications in new-generation energy devices such as solar cells and batteries. In this frame, structural analyses using X-ray–based techniques (*e.g.*, diffraction and reflectivity) are widely used for the investigation of powders and thin films to collect a variety of fundamental information. In fact, a fine control over structural characteristics of materials, such as crystalline quality (structure and imperfections of crystals), thickness of grown films and density is extremely important for the realization of devices with targeted performances. With this purpose, it was assembled a lab-made multi-purpose setup that allows to carry out measurements by exploiting different experimental techniques on X-rays for the measurement of physical characteristic of interest. After a brief introduction on the techniques and the experimental setup, we will show some measurements, performed to identify some physical properties mentioned above, for selected low-dimensional materials of energetic interest.

Investigation of the pressure evolution of the excitonic band in bare and encapsulated TMDs monolayer.

Capeccia M., D'Alò B., Stellino E., Blundo E., Polimeni A., Postorino P.
Dipartimento di Fisica, Università La Sapienza, Roma, Italia

Semiconducting Transition Metal Dichalcogenides (TMDs) are crystals with a graphene-like structure, which allows them to be exfoliated down to monolayer (1L) flakes. The latter possess a direct bandgap, which makes them promising materials for optoelectronic devices. High pressure (HP) is an effective tool to tune the electronic properties of 1L TMDs. In particular, HP photoluminescence (PL) allows us to study the evolution of the A-exciton associated with the direct bandgap. However, as pressure increases, a dramatic spectral weight transfer occurs from the A-exciton to a defect-related trion band, which prevents following the trend of the bandgap above a few tenths of GPa. To overcome this issue, we propose encapsulating 1L-TMDs with hexagonal boron nitride (hBN), which has proved to reduce the defects in TMDs at ambient conditions. We compared the HP response of bare and encapsulated flakes, obtaining a significant reduction in the rate of pressure-induced defect creation in the latter case. This investigation allows us to decouple the effects of defects from the evolution of the bandgap, paving the way to a deeper comprehension of the HP evolution PL spectrum in TMDs.

Fondazione Aula 1 - Edificio S2 **ore 09:00 – 13:30**

Sezione II
Simposio di Fisica Statistica e Sistemi Complessi
Presiedono: Spagnolo B. (Università di Palermo)
Corberi F. (Università di Salerno)

Relazioni su invito

▲ **Quantum Mpemba effect.**
Calabrese P.
SISSA
The Mpemba effect is the counterintuitive and controversial phenomenon that hot water cools faster than cold one. Here I will introduce an analogous effect recently proposed and observed in extended quantum systems in which a symmetry is explicitly broken by the initial state, but it is restored by the time evolution. To study this phenomenon we introduce a new quantity, dubbed entanglement asymmetry, which is a measure of symmetry breaking inspired by the theory of entanglement in many-body states.

▲ **Phase transitions in the nucleus of cells shape chromosome folding and function.**
Nicodemi M.
Dipartimento di Fisica, Università di Napoli Federico II e INFN, Sezione di Napoli
In the nucleus of cells, the human genome has a complex 3D organization that serves vital functional purposes as, for instance, our genes to be activated need to contact distal regulatory regions along DNA. Yet, it is largely unknown how the system self-organizes. I discuss our recent results from polymer physics, confirmed by molecular biology experiments, showing that chromosome 3D architecture is controlled by phase transitions, such as micro-phase separations or coil-globule transitions. Those results ground the comprehension of the very functioning of our genome on the principles of physics and can be successfully employed to predict, for example, how gene-neutral mutations result in diseases, such as congenital disorders and cancer, by altering the regulatory network of genes.

▲ **Alpha rhythm functions as a pacemaker for resting-state network excitability.**
de Arcangelis L., Lombardi F., Herrmann H.J., Parrino L., Plenz D., Scarpetta S., Vaudano A.E., Shriki O.
Department of Mathematics and Physics, University of Campania Luigi Vanvitelli
The alpha rhythm is a distinctive feature of the awake resting-state of the human brain. Recent evidence suggests that alpha plays an active role in information processing. However, the relationship between alpha oscillations and underlying neuronal dynamics remains poorly understood. To address this question, we investigate collective neural activity during resting wake and NREM sleep, a physiologic state with marginal presence of alpha rhythm. We show that, during resting wake, alpha oscillations drive alternation of attenuation and amplification bouts in neural activity. Our analysis indicates that inhibition is activated in pulses that last a single alpha cycle and gradually suppress neural activity, while excitation is successively enhanced over the timescales of a few alpha cycles to amplify neural activity. Furthermore, we show that long-term, intermittent fluctuations in alpha amplitude

—known as the "waxing and waning" phenomenon— are associated with an attenuation-amplification mechanism. Importantly, we do not observe such dynamics during NREM sleep. These findings suggest that the alpha rhythm functions as a "pacemaker" for the alternation of inhibition and excitation.

▲ Quantum-bounds and fluctuation-dissipation relations.

Foini L. ([1]), Pappalardi S. ([2]), Kurchan J. ([2])
([1]) *IPhT, CNRS, CEA, Université Paris Saclay, Gif-sur-Yvette, France*
([2]) *Laboratoire de Physique de l'Ecole Normale Supérieure, ENS, Université PSL, CNRS, Sorbonne Université, Université de Paris, Paris, France*

In recent years, there has been intense attention on the constraints imposed by quantum mechanics on the dynamics of many-body systems at low temperatures, triggered by the postulation and derivation of quantum bounds on transport coefficients or on the chaos rate. In this talk I will discuss the quantum fluctuation-dissipation theorem (FDT) as the principle underlying bounds on correlation time scales. By restating the problem in a replicated space, we show that the quantum bound to chaos is in fact a direct consequence of the FDT, as applied to a particular pair of two-time correlation and response functions. Encouraged by this, we will re-examine the problem of bounds on transport coefficients.

▲ Novel methods for entropy production estimation.

Baiesi M., Di Terlizzi I., Falasco G., Gironella M., Herráez-Aguilar D., Betz T., Monroy F., Ritort F.
Dipartimento di Fisica e Astronomia, Università di Padova, INFN, Sezione di Padova

We describe some effective methods for inferring the amount of dissipation in small fluctuating systems, such as molecules, cells, or driven colloids. One approach focuses on a variance sum rule: entropy production emerges as a deviation from a generalization of the free diffusion law. With a model using some assumptions, a reduced variance sum rule allows us to measure a dissipation rate of millions of kB per second from different experiments of active red-blood cells (two setups of optical tweezers and optical microscopy). A second approach applies to jump systems lacking data, in which reverse transitions are rare or unobserved. In these regimes, our lower bound estimates the entropy production rate better than direct formulas.

▲ Information filtering of high correlation matrices.

Mantegna R.N. ([1])([2]), Garcia Medina A. ([3])([4]), Miccichè S. ([1])
([1]) *Dipartimento di Fisica e Chimica Emilio Segrè, Università di Palermo, Italy*
([2]) *Complexity Science Hub Vienna, Austria*
([3]) *Centro de Investigación en Matemáticas, Unidad Monterrey, México*
([4]) *Consejo Nacional de Ciencia y Tecnología, México*

We discuss the concept of information filtering in correlation matrices describing multivariate stochastic processes monitored with limited number of records. Specifically, we investigate block diagonal and hierarchical nested stochastic multivariate Gaussian models by studying their sample cross-correlation matrix. By performing numerical simulations, we compare a filtered sample cross-correlation with the population cross-correlation matrices by using several rotationally invariant estimators (RIE) and hierarchical clustering estimators (HCE) under several loss functions. We show that the two approaches rely on different sets of eigenvectors and that sample cross-correlation filtered by RIE estimators are often outperformed by HCE estimators for several of the loss functions. We also show that for block models and for hierarchically nested block models the best determination of the filtered sample cross-correlation is achieved by introducing two-step estimators combining state-of-the-art non-linear shrinkage models with hierarchical clustering estimators.

Comunicazioni

Polymer physics of chromosome spatial organization.
Conte M., Bianco S., Chiariello A.M., Esposito A., Nicodemi M.
Dipartimento di Fisica, Università di Napoli Federico II, Italia
In the nucleus of cells, chromosomes have been discovered to self-organize into a complex spatial architecture that serves vital functional purposes as, for instance, genes have to establish specific physical contacts with their distal DNA regulators to control transcriptional activities. However, how the system self-assembles to shape the folding of our genome and its functions is only poorly understood. In this talk, I discuss principled models of interacting polymers from statistical mechanics to investigate the mechanisms whereby distal DNA sequences recognize and interact with each other. By combining polymer physics theory and computer simulations, I show that chromosome spatial organization is controlled at the single-molecule level by thermodynamic mechanisms of phase-separation transitions, which spontaneously establish contact or segregation between specific genomic sites, such as genes and their regulators. Those theories are validated against independent experiments, opening to new tools for real-world applications, such as the prediction of the effects of disease-associated mutations, linked to congenital disorders or cancer, on genome 3D structure.

Modeling chromosome organization in infected genomes with polymer physics.
Chiariello A.M., Abraham A., Bianco S., Esposito A., Vercellone F., Conte M., Nicodemi M.
Dipartimento di Fisica "Ettore Pancini", Università di Napoli Federico II and INFN, Sezione di Napoli
Within the cell nucleus of eukaryotic organisms, chromosomes are organized in a complex, non-random three-dimensional (3D) spatial structure, which is intimately linked to vital functional purposes. Indeed, a correct folding allows an efficient communication between genes and their distal regulatory elements while, if altered, can cause severe diseases. Here I will discuss how Polymer Physics, combined with Molecular Dynamics simulation and Machine-Learning–based inference, represent a powerful tool to quantitatively investigate the complexity of 3D organization of real genomes, as highlighted by recent microscopy and biochemical experiments. I will show that simple physical processes, widely studied in Statistical Mechanics, such as phase-separation of molecular aggregates and coil-globule polymer transitions, allow us to make sense of recent experimental observations including the tissue-specific DNA structure and the variability of chromatin at the single cell level. Finally, polymer models can be used to study the impact of disease-linked genetic mutations or the effect of viral infections as SARS-CoV-2, opening the way to new potential tools in Biomedicine.

Polymer physics reveals a combinatorial code linking 3D chromosome architecture to 1D chromosome features.
Esposito A.
Università degli studi di Napoli Federico II and INFN
The mammalian genome has a complex, far from random three-dimensional (3D) organization, intimately linked to vital functional processes. To understand the physical mechanisms underlying chromosome folding, polymer models from statistical physics and a variety of computational methods have been proposed. However, they usually cannot explain data at the length scale of full chromosomes. In this talk, I will show how our approach, that combines Machine Learning and Polymer Physics, can be easily extended genome-wide in order to obtain a set of polymer models that correctly explain 3D folding data of the whole genome.

The obtained polymer models are validated by making predictions on the changes of the 3D structure caused by disease-linked genomic mutations and our predictions are confirmed by independent data from cells carrying such mutations. Finally, by exploiting such a complex organization, we developed a code to predict de novo the 3D structure of an independent set of chromosomes from only their 1D epigenetic marks. Overall, our results shed light on how 3D information is encrypted in 1D via the specific combinatorial arrangement of chromosome features.

Detecting measurement-induced quantum phase transitions with Fisher information.

Di Fresco G., Spagnolo B., Valenti D., Carollo A.
Dipartimento di Fisica e Chimica E. Segré, Università degli Studi di Palermo, Italia

The interplay between a deterministic quantum evolution and a series of measurement processes can cause an abrupt change in the entanglement properties of a system. This phenomenon is called measurement-induced phase transition (MIPT). Quantum Fisher information (QFI) measures the sensitivity of a quantum system to small changes in a parameter and is widely used to detect quantum phase transitions in different situations. It is natural to ask if phase transitions driven by measurement processes can also be detected using QFI. The smoking gun signature of an MIPT is the abrupt changes in the entanglement properties of the system, usually detected through entanglement entropy. However, given the correct metrological scheme, QFI not only detects entanglement but is also a more informative measure than entanglement entropy since it detects multi-partite entanglement and highlights only the presence of useful metrological entanglement. We show that QFI can distinguish between different phases in a MIPT for a non-Hermitian one-dimensional Ising chain and show the presence of a divergence of QFI at the critical point.

Breather-enhanced Josephson thermal transport.

De Santis D. ([1]), Spagnolo B. ([1]), Carollo A. ([1]), Valenti D. ([1]), Guarcello C. ([2])
([1]) *Dipartimento di Fisica e Chimica "Emilio Segrè", Università degli Studi di Palermo, Italia*
([2]) *Dipartimento di Fisica "E.R. Caianiello", Università di Salerno, Italia*

We show that breathers, *i.e.*, fluxon-antifluxon oscillating bound states, enhance the thermal transport in thermally-biased long Josephson junctions. This provides a solitonic channel for mastering the local temperature throughout the system. The novel physical property also paves the way for a long-awaited breather detection scheme which does not require the bound state's destruction. Notably, the precise shape of the (breather-induced) local thermal peak depends on the breathing frequency. The latter quantity can thus be measured in an experiment. Then, we exploit the simultaneous action of noisy and ac forces for exciting and stabilizing the breather modes, and we demonstrate the robustness of the results in a realistic scenario.

Caos, synchronisation and control of cellular automata.

Bagnoli F.
Università di Firenze

Cellular automata are completely discrete systems, so one cannot directly apply methods developed for continuous systems. Yet, they may show a strong dependence on variations in the initial conditions, analogous to chaos in continuous systems. Moreover, they are often used as computational models of real systems and therefore it is interesting to develop control techniques, which are necessarily quite different from the usual ones. In this talk I shall review the concept of chaos indicators (Lyapunov exponents) for cellular automata, how

they are related to master-slave synchronization of replicas and how this phenomenon can be exploited to control and forecast the evolution of a system described by cellular automata.

Aula F4 - Henrietta Leavitt **ore 09:00 – 13:30**

Sezione III
Astrofisica
Presiede: Branchesi M. (GSSI, L'Aquila)

Relazioni su invito

▲ **The Low-Frequency Array (LOFAR) and the pathway to the SKA.**
Brunetti G.
INAF, Istituto di Radioastronomia, Bologna
Research in radio astronomy is undergoing a major transformation thanks to the precursors and pathfinders of the Square Kilometer Array (SKA). The pan-European LOFAR array is the world's largest radio telescope to explore the radio sky at long wavelengths and the most important pathfinder of the SKA-low. It is a network of stations, distributed across 10 Countries in Europe, that produces unprecedented data volumes and opens a new observational window of the Universe. LOFAR is driving a revolution in several fields by entering an unexplored region of observational parameters; a relevant example is provided by the first steps towards the detection of radio emission from filaments and the large-scale structure of the Universe. In this talk I will give an overview of LOFAR and of its most important aspects on the way to the SKA. In the second part I will focus on the important results that have been achieved in the field of galaxy clusters and large-scale structures, and on the main challenges that need to be addressed in the near future and in the SKA era.

▲ **A MeerKAT view of the Universe at large scales.**
Loi F., Govoni F., Murgia M., Serra P., Vacca V.
INAF, Osservatorio Astronomico di Cagliari, Italia
On 2019 MeerKAT, the South Africa-based SKA pathfinder, started to observe the sky at GHz frequencies. Since then, the acquired observations are allowing us to constrain the physics of galaxies, galaxy groups and clusters, to understand how galaxies evolve in different environments, and to study the injection mechanisms of magnetic fields at large scales. The deep high-resolution MeerKAT images are also showing new unexpected features associated with radio sources that are challenging our historical view of these objects. This contribution aims at reviewing the most striking results we are achieving with the MeerKAT telescope.

Comunicazioni

● **Cosmologia con l'intensity mapping dell'idrogeno neutro: il radiotelescopio MeerKAT e forecast per sinergie ottico-radio.**
Barberi Squarotti M., Camera S.
Università degli Studi di Torino
La struttura a grandi scale dell'universo è uno dei principali strumenti per comprendere l'evoluzione dell'universo e vincolare i parametri del modello cosmologico ΛCDM. La prossima generazione di radiotelescopi permetterà di mappare la distribuzione della materia in modo alternativo rispetto alle survey di galassie grazie alla tecnica dell'intensity mapping dell'idrogeno neutro, che consiste nel condurre osservazioni a bassa risoluzione angolare del flusso integrato nella riga a 21 cm proveniente da sorgenti non risolte. L'esperimento

MeerKAT, precursore dello Square Kilometer Array Observatory (SKAO), ha già completato due stagioni osservative che hanno permesso di testare le tecniche di pulizia dei dati necessarie per questo tipo di osservazione e ottenere le prime detection del segnale cosmologico. Si presentano i risultati delle analisi sulle mappe del 2019, il cui scopo era migliorare la comprensione di effetti sistematici ed estrarre lo spettro di potenza. Inoltre si mostrano i forecast sulla possibilità di vincolare il parametro di non gaussianità primordiale con la tecnica multi-tracciatore applicata a misure di intensity mapping e survey di galassie.

The MISTRAL instrument: a W-band Lumped Elements Kinetic Inductance Detectors Array for mm-wave astronomy.

Coppolecchia A. ([1])([2]), Barbavara E. ([1]), Battistelli E.S. ([1])([2]), de Bernardis P. ([1])([2]), Cacciotti F. ([1]), Capalbo V. ([1]), Carbone A. ([1]), Carretti E. ([4]), Columbro F. ([1])([2]), Cruciani A. ([2]), D'Alessandro G. ([1])([2]), De Petris M. ([1])([2]), Govoni F. ([3]), Isopi G. ([1]), Lamagna L. ([1])([2]), Marongiu P. ([3]), Mascia A. ([3]), Masi S. ([1])([2]), Molinari E. ([3]), Murgia M. ([3]), Navarrini A. ([3]), Novelli A. ([1]), Occhiuzzi A. ([1]), Orlati A. ([5]), Paiella A. ([1])([2]), Pettinari G. ([6]), Piacentini F. ([1])([2]), Pisanu T. ([3]), Poppi S. ([3]), Porceddu I. ([3]), Ritacco A. ([3]), Schirru M.R. ([3])
([1]) *Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italy*
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([3]) *INAF - Osservatorio Astronomico di Cagliari, Selargius, CA, Italy*
([4]) *INAF - Istituto di Radioastronomia, Bologna, Italy*
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([6]) *Consiglio Nazionale delle Ricerche, Istituto di Fotonica e Nanotecnologie, Roma, Italy*

The MIllimeter Sardinia radio Telescope Receiver based on Array of Lumped elements KIDs (MISTRAL) is a W-band (77–103 GHz) camera working at the Gregorian focus of the 64 m aperture Sardinia Radio Telescope (SRT), located in Sardinia (Italy) and run by INAF. The 400 elements detector array consists of Ti/Al bi-layer Lumped Elements Kinetic Inductance Detectors (LEKID). The MISTRAL instrument consists of a cryogenic system, based on a Pulse Tube cryocooler, hosting the re-imaging cold optics at 4 K, the filter chain and the multi-stage sub-K ^{3}He cooler type twin GL10 that provides the 0.2 K operation temperature for the detectors array. MISTRAL provides a 4' field of view with 12" angular resolution. This allows to probe a number of astrophysical processes in galactic and extragalactic enviroments. After technical and scientific commissioning in 2023, MISTRAL will be open to proposals from scientists as a facility instrument. In this contribution, we will describe the MISTRAL instrument, the laboratory performance and the integration with the SRT system; we will also review the observation plan for the technical and scientific commissioning.

Radio halos in galaxy clusters: the puzzling case of Abell 2142.

Bruno L.
Università di Bologna, Dipartimento di Fisica e Astronomia, DIFA-UNIBO e Istituto Nazionale di Astrofisica, Istituto di Radioastronomia, INAF-IRA

Clusters of galaxies allow us to probe the interplay between thermal and non-thermal components of the intra-cluster medium (ICM). Turbulence induced by mergers of clusters in the ICM can re-accelerate aged particles and trigger the formation of diffuse synchrotron radio sources. These provide information on the energy transfer mechanisms and magnetic fields on cosmic scales. Diffuse sources in the form of giant radio halos (RHs) and mini-halos (MHs) are found in major merging clusters and weakly perturbed relaxed systems, respectively. Despite this classification, a handful of hybrid RH-MH sources of unclear origin are known. Abell 2142 (A2142) is a puzzling cluster that exhibits intermediate properties between classical major merging and relaxed systems. It was known to host a peculiar hybrid

halo. The unprecedentedly high sensitivity of LOFAR below 200 MHz allowed us to detect a third elusive radio component, which makes A2142 a unique case in the field of diffuse sources. We present the non-thermal properties of the three-component hybrid halo and its thermal ICM counterpart, and discuss possible scenarios that triggered re-acceleration processes on different scales.

Deep Focus: A meta-learner solving inverse problems based on deep learning paradigms. An application to astronomical radio interferometry.

Delli Veneri M. ([1]), Dosi A. ([2]), Brescia M. ([2]), Guglielmetti F. ([3]), Longo G. ([2]), Russo G. ([2])

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([2]) *University of Naples Federico II, Department of Physics "Ettore Pancini"*

([3]) *European Southern Observatory, Garching*

Current and forthcoming astronomical observatories are rapidly increasing the quantity, velocity and complexity of their data products transitioning in the Big Data regime. Extracting knowledge from scientific data produced by such instruments involves the resolution of ill-posed inverse problems traditionally solved with algorithms which cannot cope anymore with the rising data complexity. We present Deep Focus (DF), a meta-learner for the resolution of inverse problems in astrophysical imaging. The method can construct and optimize Deep Learning (DL) architectures (Res-Nets, U-Nets, VGG-Nets, Dense-Nets, Autoencoders) from a large pool of model hyperparameters. Leveraging multi-GPU environments, and a Bayesian hyperparameter optimization strategy, DF can search for the most performing architecture for a given problem. We tested the performances of DF in deconvolving 3D ALMA mock data cubes, containing high-redshift sources, obtaining better reconstruction capabilities compared to other DL architectures and achieving two order of magnitude improvements in speed and reconstruction quality with respect to the tCLEAN algorithm.

Morphology of Planck-SZ galaxy clusters with Zernike polynomials.

Capalbo V. ([1]), De Petris M. ([1]), Ferragamo A. ([1]), Cui W. ([2])([3]), Ruppin F. ([4]), Yepes G. ([3])

([1]) *Dipartimento di Fisica, Sapienza Università di Roma, Italia*

([2]) *Institute for Astronomy, University of Edinburgh, Royal Observatory, Edinburgh, UK*

([3]) *Departamento de Física Teórica and CIAFF, Módulo 8, Facultad de Ciencias, Universidad Autónoma de Madrid, Spain*

([4]) *University of Lyon, UCB Lyon 1, CNRS/IN2P3, IP2I Lyon, France*

Inferring the dynamical state of galaxy clusters is a crucial stage to correctly estimate the mass of those systems and use them as cosmological probes. Several studies are focused on defining efficient methods to extract information on the dynamical state from observational data and among these, the morphological analysis of projections maps is largely used especially when dealing with large samples of observed objects. We recently developed a new method to recover morphological features in 2D projections maps of clusters by means of the Zernike polynomials. These functions are used in several fields (*e.g.*, adaptive optics, optometry, medicine) as shape descriptors due to some simple analytical properties. Here we present the first application of this method on a large set of observed galaxy clusters through the Sunyaev-Zel'Dovich effect (SZ). Our dataset is composed by local ($z < 1$) clusters selected from the *Planck*-SZ catalogue along with hydro-simulated objects used to calibrate the method and test the efficiency of the Zernike morphological analysis in discriminating different dynamical populations in the real clusters sample.

● **Analysis on f multi-wavelength synergies for the mitigation of systematics.**
Ingrao R., Camera S.
Università degli studi di Torino
I will present an analysis about the removal of observational systematic effects in measurements of the weak gravitational lensing effect of cosmic shear for cosmological studies. It stems from synergies between radio and optical/near-infrared observations, like those that will be carried out by the Euclid satellite and the SKA Observatory, with a focus on cosmological parameter forecasting. In particular, the primary case of study is the forecast of the dark energy equation-of-state parameters through MCMC algorithms. The weak lensing optimal capabilities as a probe for the growth of cosmic structures and background evolution, together with the feasibility for high-accuracy cosmic shear surveys offered by upcoming new experiments both in radio and optical bands, made this type of multi-wavelength analyses a field of great interest for today's cosmology. In this optics, works such as mine would offer contributions on how to make the most of the unique approaches and capabilities that the aforementioned experiments will offer.

Relazioni su invito

▲ **The Universe in a box: astrophysics and cosmology with numerical simulations.**
Borgani S.
University of Trieste and INAF
Numerical simulations arguably represent nowadays the most advanced instruments to capture the complexity of the physical processes driving the cosmic structures over wide dynamic ranges. In my talk I will review recent results, with a focus on the astrophysics of galaxy clusters and cosmology. I will highlight how such simulations are both unique to understand the astrophysics of structure formation, and of invaluable support for the exploitation of ongoing and forthcoming cosmological surveys. I will finally discuss the perspectives of HPC in cosmology, both in terms of access to large computing infrastructures, and of specific expertise for the development of innovative algorithmic solutions.

▲ **Modeling the multi-phase properties of galaxies —lessons learnt and future perspectives.**
De Lucia G.
INAF - Astronomical Observatory of Trieste
Understanding the physical mechanisms driving the formation and evolution of galaxies in a cosmological context represents one of the most important yet unresolved questions of modern astrophysics. Different methods have been developed over the years to link the physical properties of galaxies to the dark matter haloes in which they reside. I will review recent developments of our model for GAlaxy Evolution and Assembly (GAEA), and discuss the role of different physical processes in shaping the measured evolution of the galaxy stellar mass function, of the mass metallicity relation, as well as of the observed scaling relations involving the multi-phase gaseous properties of galaxies. I will conclude by discussing open problems and future perspectives.

▲ **The Euclid mission: status and cosmological goals.**
Guzzo L. on behalf of the Euclid Collaboration
Università degli Studi di Milano e Euclid Consortium member institutions
Euclid is the next cosmological mission of the European Space Agency (ESA). At the time of reading this abstract, Euclid will have been operating since around two months in its

orbit around the L2 Lagrangian point, following its launch in early July 2023 from Kennedy Space Centre in Florida. In this talk, I will give an overview of the Euclid project, report on the status of the mission and review its cosmological goals. As per its name, Euclid will map the geometry of the Universe, reconstructing the three-dimensional distribution of both dark and visible matter through measurements of weak gravitational lensing and galaxy clustering over 15000 square degrees. Providing the tightest ever estimates of the rates of cosmic expansion and structure growth, such measurements will represent an unprecedented test of the current standard model of cosmology to understand the origin and nature of its obscure ingredients, dark matter and dark energy.

Comunicazioni

Risultati preliminari sulla calibrazione e sulla validazione delle prestazioni dello strumento NISP di EUCLID utilizzando dati simulati.

Delucchi G. ([1])([2]), Davini S. ([2]), Tosi S. ([1])([2]), Testera G. ([2])
([1]) *Università di Genova, Italia*
([2]) *INFN Sezione di Genova, Genova, Italia*

Euclid è una missione ESA il cui lancio è previsto per il luglio 2023. La calibrazione e la validazione in volo di diverse grandezze sono di fondamentale importanza per valutare le prestazioni del rivelatore e della strumentazione per garantire il raggiungimento degli obiettivi scientifici della missione. In questa presentazione, illustrerò il mio lavoro all'interno della collaborazione dell'Instrument Operation Team (IOT): mostrerò alcuni risultati preliminari ottenuti utilizzando il software di validazione su dati simulati per lo strumento NISP (Near-Infrared PhotoSpectrometer) di Euclid.

A versatile software framework for astronomical scientific and instrumentation data analysis.

Riccio G. ([1]), Cavuoti S. ([1]), Brescia M. ([2]), Pietroni S. ([1])
([1]) *INAF - Osservatorio Astronomico di Capodimonte, Napoli*
([2]) *Università degli Studi di Napoli "Federico II"*

In the last two decades, Astronomy has been the scene of the realization of panchromatic surveys, with sophisticated instruments acquiring a huge amount of exceptional quality data. This poses the need to integrate advanced methodologies for the automatic exploration of huge data archives, and to have efficient short- and long-term monitoring and diagnostics systems to keep the quality of the observations under control, ensuring correct maintenance of all components and the good health of scientific data over time. AIDA (Advanced Infrastructure for Data Analysis) is a portable and modular web application, designed to provide an efficient and intuitive software framework to support instrumental data monitoring and diagnostics, as well as scientific data quality analysis. Its versatility makes it possible to extend its functionalities, by integrating and customizing monitoring and analysis systems. Due to these properties, a specific version of AIDA is already the official monitoring and analysis tool for the ESA Euclid space mission and another one is going to be used for the commissioning of the V. Rubin Telescope.

Predizioni per analisi combinate di conteggi di galassie e lenti gravitazionali del campione spettroscopico di galassie di Euclid.

Meola F., Camera S.
Università degli Studi di Torino

Obiettivo: il telescopio spaziale Euclid indagherà l'evoluzione dell'universo, la materia oscura e l'energia oscura, misurando la forma e il redshift di galassie. Sfrutterà principalmente un

campione di galassie fotometriche. In questo progetto si andrà a confrontare l'analisi del campione fotometrico con l'analisi di un campione spettroscopico. Metodo: si confronteranno i due campioni facendone una tomografia in redshift e sfruttando gli spettri angolari della funzione di correlazione tra bin e l'analisi 3×2 pt. Si andrà a ricavare il rapporto segnale/rumore tramite la matrice di covarianza e le incertezze sui parametri cosmologici e si confronteranno i valori ottenuti, andando a studiare i metodi per aumentare le potenzialità del campione spettroscopico. Risultati: lo svantaggio del campione spettroscopico è il ridotto numero di galassie rispetto al campione fotometrico. Per aumentare le potenzialità del campione spettroscopico si può raffinare il binnaggio tomografico oppure diminuire l'incertezza sulla misura del lensing, sfruttando il kinematic lensing.

Modelling and estimation of the anisotropic galaxy 3-point correlation function.

Farina A. ([1])([2])([3]), Veropalumbo A. ([2])([3]), Branchini E. ([1])([2])
([1]) *Dipartimento di Fisica, Università degli Studi di Genova, Genova, Italy*
([2]) *INAF - Osservatorio Astronomico di Brera, Milano-Merate, Italy*
([3]) *INFN - Sezione di Genova, Genova, Italy*

The galaxy 3-point correlation function (3PCF) is a powerful tool for breaking degeneracies between cosmological and nuisance parameters and, thus, constraining the nature of Dark Energy. To this end, we present a routine that enables modelling the statistical anisotropies induced by redshift-space distortions on 3PCF. This approach, based on the 2D-FFTLog algorithm, allows us to numerically determine the tripolar spherical harmonics expansion of the 3PCF starting from its Fourier space analogue, the bispectrum. In addition, we implement for the first time the anisotropic Slepian-Eisenstein estimator, which enables measuring the redshift-space galaxy 3PCF in $\mathcal{O}(N^2)$ time, with N number of galaxies. As a reliability test on both estimator and theoretical approach, we perform a likelihood analysis on a suite of 298 Minerva dark matter halo catalogs, finding non-biased estimates for the main cosmological parameters. This result, hence, opens up the possibility of performing a fully anisotropic joint 2 and 3PCF analysis, that would allow us to constrain the evolution history of the Universe with unprecedented precision.

Sample optimization for the detection of relativistic effects with galaxy power spectrum measurements.

Montano F., Camera S.
Dipartimento di Fisica, Università degli Studi di Torino

In measurements of cosmological interest, the density contrast of galaxies is used to map the matter distribution in the Universe. The relation between the density contrast of matter and that of galaxies has some corrections, amongst which a purely imaginary term due to general relativity. Such an effect, which brings additional contributions to the power spectrum of galaxies, is sub-dominant compared to the standard Newtonian contributions. This work focuses on optimizing the sample to be studied to measure such a relativistic effect in the power spectrum of galaxies. The relativistic effect depends mainly on the characteristics of the investigated sample (*e.g.*, luminosity function). In fact, it is the large-scale part of the power spectrum that is mainly affected by this correction. I will present forecasts for the detection of the relativistic effect for some future galaxy surveys by measurements of the auto- and cross-correlation power spectra of several galaxy samples. Cross-correlation measurements appear to be more promising than auto-correlation measurements, as they allow the studied effect to be detected even at smaller scales.

Aula F3 - Maria Telkes **ore 09:00 – 13:30**

Sezione IV
Geofisica e fisica dell'ambiente
Presiede: Scarpa R. (Università di Salerno)

Relazioni su invito

▲ **Determinazione del flusso di calore tramite termocamera mobile, drone e satellite: Applicazione ai Campi Flegrei.**
Marotta E.
Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Napoli Osservatorio Vesuviano
La misura delle variazioni di flusso di calore dal suolo fornisce, in aree vulcaniche quiescenti, un contributo fondamentale alla comprensione dei processi vulcanici e costituisce uno dei parametri di riferimento per la determinazione dello stato di attività di un vulcano. Esso, in un regime puramente conduttivo, è direttamente legato al gradiente termico superficiale: uno dei primi metodi utilizzati per la sua stima è proprio basato sulla misura di tali gradienti, un altro si basa invece sulla misura del flusso di CO_2. Tali metodi necessitano lunghe campagne di misure puntuali, pertanto è nata la necessità di sviluppare una nuova tecnica per la determinazione del flusso di calore che richiedesse tempi minori e fosse basata su misure areali e non puntuali per consentire un monitoraggio di routine più speditivo e permettere il monitoraggio di evoluzioni anche rapide dell'attività vulcanica. È stato dimostrato come sia possibile stimare il flusso di calore a partire da misure superficiali della temperatura utilizzando termocamere mobili e si sta sperimentando la possibilità di utilizzare droni e satelliti come mezzo per effettuare misure delle temperature superficiali.

▲ **Lava flow hazards: Past, present and future perspective.**
Cappello A.
Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo
In the last decades, the assessment of volcanic hazards has become one of the most rapidly developing topics in volcanology, especially for risk prevention and mitigation actions. Different numerical methods and tools have been developed to help scientists and decision-makers to better understand the evolution of eruptive phenomena and quantify the related hazards and risk. In the case of high-risk phenomena, such as lava flows, predicting their spatial and temporal evolution and determining the potentially affected areas is fundamental in supporting every action directed at mitigating the risk, as well as for environmental planning. Here we will review the most relevant models and tools that have been developed for the lava flow hazard monitoring and assessment, including the lessons learnt during recent eruptive emergencies worldwide. Moreover, we will present the preliminary results of the INGV project PANACEA, which aims to develop new capabilities for volcanic and seismic disaster management at Mount Etna, based on multi-hazard analyses and the quantification of cascading effects scenarios that will be also directly usable for multi-risk assessment.

▲ **Earth environmental monitoring using multi-source multi-temporal satellite imagery.**
Ganci G.
Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo
Satellite remote sensing has become a strong focus of global interest, offering valuable tools to systematically observe and analyze the Earth's surface and supporting responses to natural

risks and disasters. The current ever-growing multi-source capability of orbiting instruments, including hundreds of micro and nano satellites, has been requiring new analysis approaches for the synergistic processing and joint interpretation of this large and heterogeneous amount of data. Here a review of processing techniques for satellite data analysis and environmental monitoring will be presented, together with the emergent use of the newest machine learning and soft computing technologies. Different applications of multi-temporal multi-source satellite imagery analysis will be shown including: volcanic hazards, forest fires, damage mapping and waste disposal sites characterization. Moreover the methodology devised in the framework of the INGV SAFARI project, which designs a comprehensive space-based strategy for next-generation quantitative natural hazard monitoring integrating the most recent satellite imagery capabilities and the relative products, will be proposed.

Comunicazioni

Observations on the rotational seismic wavefield recorded in the Campi Flegrei volcanic area.

Galluzzo D. ([1]), La Rocca M. ([2]), Gaudiosi G. ([1]), Nardone L. ([1])
([1]) *Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Napoli, Osservatorio Vesuviano*
([2]) *Università della Calabria, Cosenza*

In recent years, the use of rotational seismometers has been improved to investigate the full wavefield of earthquakes through the joint use of transational and rotational components of motion. The preliminary results shown in the present communication refer to the analisys carried out on the data recorded by a rotational seismometer installed in the Campi Flegrei volcanic area. Starting from the first months of the year 2021, the first rotational seismometer (Lunitek Tellus R based on magnetichydrodynamic technology) was installed close to a broad band sensor Guralp CMG40T (60 s) and an Episensor Kinemetrics. The collected data is composed by the low magnitude local seismicity (MDmax = 3.6) with hypocentral depths between 0.3 and 4 km b.s.l. For the selected earthquakes (MD > 1.7), coherence and cross-correlation methodologies were applied to obtain directional features of incoming recorded wavefield. The joint use of rotational and accelerometric sensors confirmed the possibility of estimating directinal features of the incoming wavefront and highlighted correlated phases on the coda of seismograms providing useful indications about the diffuse wavefield recorded in the investigated area.

Tecniche GNSS-RTK per lo studio del bradisismo flegreo.

Moretti P.
Dipartimento di Scienze e Tecnologie, Università degli Studi del Sannio, INGV, Sezione Irpina e INGV, Sezione di Napoli-Osservatorio Vesuviano

Il presente contributo, relativo al Corso di Laurea Magistrale in Scienze e Tecnologie Geologiche, mira a sperimentare un innovativo sistema di monitoraggio delle deformazioni del suolo dei Campi Flegrei con tecniche GNSS di precisione. Tali tecniche potranno offrire, in tempi rapidi, importanti informazioni sulla dinamica del bradisismo flegreo per la corretta gestione e pianificazione di possibili scenari di emergenza. La ricerca e la sperimentazione sul campo è stata possibile grazie alla collaborazione con la Sezione Irpina e la Sezione di Napoli dell'Istituto Nazionale di Geofisica e Vulcanologia (INGV). Infatti, l'oggetto degli studi si colloca nell'ambito delle attività istituzionali dell'INGV legate alla sorveglianza delle aree vulcaniche attive italiane.

È in atto la pressurizzazione di una camera magmatica profonda sotto i Campi Flegrei? Una possibile risposta dall'analisi dei dati DInSAR di spostamento del suolo.

Crescentini L., Amoruso A.
Dipartimento di Fisica, Università di Salerno, Italia

Viene confrontato lo spostamento del suolo nei Campi Flegrei durante il periodo 1993–2000, caratterizzato da subsidenza, con quello durante il sollevamento tutt'ora in atto. I dati sono stati ottenuti dall'analisi DInSAR di immagini acquisite dai satelliti ERS1/2 ed ENVISAT (forniti da IREA/CNR) per la subsidenza e Sentinel 1A per il periodo 2015–2022. Poiché le direzioni delle linee di vista non coincidono, calcoliamo inizialmente gli spostamenti approssimati lungo le direzioni verticale e Ovest-Est per i due periodi. Le evoluzioni temporali degli spostamenti dei singoli pixel danno origine a due matrici di dati, una relativa al 1993–2000, l'altra al 2015–2022. Applichiamo quindi un'analisi EOF (Empirical Orthogonal Functions) a ciascuna delle due matrici, in modo da scomporle in modi evolutivi mutuamente non correlati, e utilizziamo solo il primo dei modi così ricavati, perché rende conto di quasi tutta la dinamica deformativa ed è l'unico che rappresenta andamenti pluriennali. Si è così ottenuta per il periodo 2015–2022 un'evidenza diretta dell'attività di una sorgente pressurizzata posta circa 8 km sotto i Campi Flegrei, non coinvolta in modo rilevabile durante la subsidenza.

Clusterizzazione di mappature termiche da drone per la ricostruzione temporale del flusso di calore dal suolo.

Peluso R.
Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Napoli Osservatorio Vesuviano

Le mappature termiche da drone permettono di ottenere rapidamente delle mappe di temperatura superficiale su aree anche grandi. In ambienti vulcanici si può utilizzare la misura della temperatura superficiale per ottenere una stima del flusso di calore proveniente dal suolo, quando ripetuto nel tempo questo processo permette di stimare anche gli andamenti temporali del flusso. Per fare ciò è però necessario separare le zone fredde o con caratteristiche fisiche diverse da quelle calde all'interno di ogni mappatura termica. Sono stati quindi sviluppati dei software basati su semplici algoritmi di segmentazione e clusterizzazione in grado di raggruppare i pixel di ognuna delle zone a temperatura anomala sulle singole immagini formando dei cluster. In seguito essi vengono ulteriormente raggruppati per permettere l'individuazione delle medesime zone anomale su immagini diverse al fine di ottenere l'andamento temporale delle dimensioni delle singole zone ed il flusso di calore ad esse collegato. I software sviluppati si basano su librerie standard open source e su algoritmi normalmente utilizzati per la manipolazione di immagini visibili.

AI-based emulators for fast simulations of lava flows.

Amato E. ([1])([2]), Zago V. ([1]), Del Negro C. ([1])
([1]) *Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo, Sezione di Catania, Catania, Italy*
([2]) *Department of Mathematics and Computer Science, University of Palermo, Palermo, Italy*

Lava flows are complex fluids including very high viscosities, solid-fluid interactions, and free-surface flows. The simulations of these flows constitute a challenge for Computational Fluid Dynamics (CFD). Smoothed Particle Hydrodynamics (SPH), a Lagrangian mesh-free numerical method based on a discrete approximation of the Navier-Stokes equations, is a consolidated approach for addressing this kind of problems. However, SPH simulations require long run times and large computational resources. Any speed-up of the simulations is usually obtained by simplifying the model or boosting the computational resources. Here,

we discuss a change of paradigm, where instead of relying on upgrading the hardware to make computations faster, we use Artificial Intelligence (AI) to reduce the amount of computation needed in the first place. AI algorithms can be trained over SPH simulated data to emulate the behavior of the model in a faster way. Models obtained in this way are called emulators. Here, we present an AI-based emulator for a SPH model, and validate it with respect to some benchmark tests for viscous fluids, and compare the results with those obtained from the SPH model.

Dynamic strain anomalies detection at Stromboli before 2019 vulcanian explosions using machine learning.

Di Lieto B. ([1]), Romano P. ([1]), Scarpetta S. ([2]), Messuti G. ([2]), Sangianantoni A. ([1]), Scarpa R. ([2])

([1]) *Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Vesuviano, Napoli, Italia*
([2]) *Dipartimento di Fisica "E.R. Caianiello", Università degli Studi di Salerno, Fisciano, Italia*

Characterizing the dynamics of explosive activity is impelling to build tools for hazard assessment at open-conduit volcanoes: machine learning techniques are a feasible choice. During the 2019 Stromboli experienced two paroxysmal eruptions, occurred in two different volcanic phases, giving us the possibility to conceive and test an early-warning algorithm on a real use case. Among the changes observed in the weeks preceding the first paroxysm, one of the most significant is represented by the shape variation of the ordinary minor explosions, filtered in the very long period (2–50 s) band, recorded by a Sacks-Evertson strainmeter installed nearby. Starting from these observations, the usage of two independent methods to classify strain transients falling in the ultra long period (50–200 s) frequency band, allowed us to validate the robustness of the approach. This classification leads us to establish a link between VLP and ULP shape variation and volcanic activity, especially related to the first paroxysm. Previous warning times at Stromboli are of a few minutes only, while our approach could permit to anticipate this time to several days by detecting medium-term shape changes.

Volcanic-induced fire hazard at Stromboli Island.

Guardo R., Bilotta G., Ganci G., Zuccarello F., Cappello A.

Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo, Catania, Italy

Forest fire propagation models have been extensively researched and utilized in recent years, using approaches that range from complex physical models to simpler graph or cellular automata-based models. These models take into account several input parameters, such as vegetation flammability, tree types, wind, humidity, radiant capacity, and topography, to accurately simulate fire propagation. Integrated with Geographic Information Systems, these models can also be used to classify soil and map burned areas. The high availability of low-cost high-performance parallel computing hardware has made cellular automata-based simulations more accessible, cost-effective, and capable of simulating fire propagation under various environmental conditions. However, a specific model for volcanic-induced fires is still missing. Leveraging our experience with modeling lava flows and estimating the associated hazard using cellular automata (GPUFLOW), our work aims to develop a similar methodology to generate fire hazard maps on Stromboli Island, using a specifically designed cellular automaton to address the limitations of accessibility, usability, and computational costs of existing applications.

Volcanic surface changes by Pleiades satellite data.

Spinetti C. ([1]), Bisson M. ([2]), Palaseanu-Lovejoy M. ([3])
([1]) *Istituto Nazionale di Geofisica e Vulcanologia, Sezione ONT, Roma, Italy*
([2]) *Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Pisa, Pisa, Italy*
([3]) *U. S. Geological Survey, Reston, VA 20192, USA*

Active volcanic areas are frequently affected by surface changes due to erupted products such as lava flows or fallout deposits. Remote sensing makes it possible to overcome field difficulties of inaccessible areas and allows measurements of areas and volumes of the erupted material. In this communication, stereo images pairs of the Pleiades satellites acquired on the volcanic areas of Mt. Etna and Stromboli have been taken into consideration. The stereo pairs of the Pleiades (1&2 and 2&3) were processed by using the NASA Ames Stereo Pipeline (ASP), an open source automated geodesy suite of stereophotogrammetry tools that process stereo images with or without accurate camera pose information. A 3D point cloud is the output obtained through a triangulation combining ephemeris/spacecraft attitude information, sensor model. Comparing the resulting surfaces, the areas and volumes affected by changes are calculated. These results, discussed and compared with available field data, can help to better understand the impact of the event and provide indications useful in a territory planning aimed to mitigate the effects of such calamitous events.

22 years of continuous GNSS observations at Mt. Etna volcano.

Palano M., Pezzo G., Chiarabba C.
Istituto Nazionale di Geofisica e Vulcanologia

Mt. Etna volcanic activity has been characterized, in the last two decades, by more than 150 paroxysmal events (from moderate to intense and impulsive explosive activity, coupled sometime to voluminous lava flows) as well as by some large eruptive events involving the upper sector of the northern and southern flanks of the volcano, along with the summit craters. Taking advantage of an extensive dataset of continuous GNSS stations covering the entire volcano edifice, we propose an unprecedented and detailed picture of different deformative stages. We detected a total of 59 different ground deformation phases consisting in 29 inflation phases, 21 deflation phases, 5 magmatic intrusions and 4 periods with no significant deformation. The surface deformation for each detected phase was used to constrain isotropic half-space elastic inversion models, therefore providing significant constraints on subsurface Mt. Etna's magmatic storages. The achieved results have been integrated with recent tomographic models in order to provide an exhaustive interpretative model into the general volcano-tectonic context of Mt. Etna and in turn, new insight on hazard assessment.

Measurement of ^{222}Rn concentration in recent eruptive products of Mt. Etna volcano by gamma spectrometry.

Rapisarda G.G. ([1])([2]), Terray L. ([3])([4]), Giammanco S. ([5]), Romano S. ([1])([2])([6]), Costa M. ([1])([2]), Stefanescu Miralles G. ([1])([2])Breton V.([4]), Gauthier P.J. ([3])
([1]) *Dipartimento di Fisica e Astronomia "E. Majorana", Università di Catania, Catania, Italy*
([2]) *INFN-LNS, Catania, Italy*
([3]) *Laboratoire Magmas et Volcans, CNRS, IRD, OPGC, Université Clermont Auvergne, Clermont-Ferrand, France*
([4]) *Laboratoire de Physique de Clermont, CNRS/IN2P3, Université Clermont Auvergne, Clermont-Ferrand, France*
([5]) *Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Catania, Catania, Italy*
([6]) *CSFNSM, Catania, Italy*

Several ash and lava samples from the Mt. Etna 2021/2022 activity have been analyzed by means of gamma-ray spectrometry using the HpGe detector available at the LARA labora-

tory of INFN-LNS. These measurements aim to the evaluation of the ^{222}Rn concentration in the erupted magma samples. The results have shown an interesting disequilibrium within nuclide activities in the ^{238}U decay chain. The obtained results together with volcanological inputs can allow us to infer interesting information about the dynamics of gas and magma transfer inside the volcano during the eruption.

Aula F7 - Giovanna Mayr **ore 09:00 – 13:30**

Sezione V

Biofisica e fisica medica

Presiede: Bellotti R. (Università di Bari e INFN, Sezione di Bari)

Relazioni su invito

▲ **Emerging technologies in particle therapy.**

Durante M.

GSI Helmholtzzentrum für Schwerionenforschung and University Federico II

Cancer therapy with accelerated charged particles is one of the most valuable biomedical applications of nuclear physics. The technology has vastly evolved in the past 50 years, the number of clinical centers is exponentially growing, and recent clinical results support the physics and radiobiology rationale that particles should be less toxic and more effective than conventional X-rays for many cancer patients. Charged particles are also the most mature technology for clinical translation of ultra-high dose rate (FLASH) radiotherapy. However, the fraction of patients treated with accelerated particles is still very small and the therapy is only applied to a few solid cancer indications. The growth of particle therapy strongly depends on technological innovations aiming to make the therapy cheaper, more conformal, and faster. The most promising solutions to reach these goals are superconductive magnets to build compact accelerators; gantryless beam delivery; online image-guidance and adaptive therapy with the support of machine learning algorithms; and high-intensity accelerators coupled to online imaging.

▲ **Status and perspectives on FLASH radiotherapy: overview of the FRIDA-INFN Collaboration activities.**

Sarti A.

Sapienza Università di Roma e INFN Sezione di Roma 1 - Roma

Since 2019, a huge experimental effort is ongoing to understand and quantify/characterise the considerable normal tissue sparing effect observed whenever treatments are delivered in a single fraction with dose rates much larger with respect to the conventional ones. This so-called "FLASH effect" has the potential to significantly widening the therapeutic window of EBRT and re-shaping the future of radiation treatments especially with charged particles. The FRIDA (Flash Radiotherapy with hIgh Dose-rate particle beAms) Collaboration initiative is devoted to the study of several key aspects related to this potential revolution. FRIDA is addressing: the mechanistic understanding and modelling of the effect; the beam delivery techniques needed to trigger the FLASH condition; the beam monitoring and dosimetry techniques capable of sustaining very high dose rates (scintillators, air luminescence detectors, silicon detectors, SiC, alanine pellets, ICT systems); the development of software tools needed for FLASH treatments planning. All these activities will be reviewed in the context of the international effort devoted to the FLASH therapy understanding and clinical translation.

▲ **Image analysis approaches to quantify the effects of ionizing radiation on microtubules and membranes.**

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The description of the dose-effect dynamics on new targets of ionizing radiation demands evaluation of structural damage borne to cellular structures. The development and availability of advanced microscopy techniques (Confocal Microscopy, STORM, AFM, etc.) make the evalutation of such effects possible from the quantitative analysis of observable geometrical properties induced on the cellular structures like cell membrane, actine fibers and microtubules. Results of dose-effect dynamics on tumoral and non-tumoral cells irradiated with different radiation types (X, proton, electrons), and following different delivery modalities such as Flash radiotherapy *vs.* Conventional RT, will be presented. These results include pattern analysis of actine fibers showing disruption of cytoscheletal features or microtubule curvature modification that reveal damages delivered to their tubuline-based structure.

Comunicazioni

External beam radiotherapy with electrons of low (IOeRT) and high (VHEE) energies: status and prospects for conventional and FLASH irradiations.

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Cancer treatment field is in continuous development aiming at improving the tumor control probability, reducing the normal tissues complications and increasing the expectancy and quality of life of the patients. In this context, today, there is a renewed interest on both low (Intra Operative Radio Therapy-IORT applications) and Very-High Energy Electron (VHEE) beams especially due to the possibility to deliver them at FLASH intensities. The specific characteristics of the electron's interactions with matter can be exploited to provide effective alternatives to standard RT and PT treatments and, among the three, can be provided by the technology that is most easily adaptable for FLASH treatment deliveries. In this contribution we investigate the efficiency achievable in IORT and VHEE treatments at both conventional and FLASH regime using a GPU-based fast Monte Carlo (MC), as a tool for dose calculation and treatment optimization. The results obtained for Partial Breast Irradiations and the treatment of pancreatic and lung cancer will be compared with the state-of-the-art RT and PT technologies.

Experimental characterization of plastic scintillators at flash regime.

Cavalieri A. ([1]), Bisogni M.G. ([1])([2]), Ciarrocchi E. ([1])([2]), Del Sarto D. ([3]), Di Martino F. ([2])([3]), Massa M. ([2]), Moggi A. ([2]), Morrocchi M. ([1])([2]), Pensavalle J.H. ([2])([3]), Ravera E. ([1])([2])

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FLASH radiotherapy shows a higher healthy tissues sparing compared to the conventional radiotherapy. To obtain the so-called FLASH effect the dose rate must be higher than 40 Gy/s and a dose of at least 10 Gy must be delivered in less than 200 ms. For electron LINAC pulsed beams, the FLASH conditions cause saturation in standard ion chambers. Thanks to their fast decay times (ns), we have proposed plastic scintillators as online dosimeters for FLASH beams. We studied two scintillating fibers of different volumes and emission spectra (a blue fiber with emission peak at 450 nm and a green one with peak at 530 nm). The measures were made using the ElectronFlash LINAC located at the Centro Pisano per la Flash Radiotherapy (CPFR) in Santa Chiara University Hospital. The signal emitted by the scintillating fibers was read by a CCD. To evaluate the saturation, we increased the dose per pulse reaching values higher than 20 Gy per pulse. A linear response was observed for both fibers for dose per pulse up to 15 Gy and a modest saturation at 20 Gy that can be corrected with calibration.

The role of Monte Carlo simulations in the characterization of diamond integrated devices for hadrontherapy.

Bianchi L.

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The fast development of new radiation therapy techniques led to a common goal: decrease the absorbed dose to healthy tissues without compromising the prescribed target coverage. The only conventional dosimetry is not enough for a comprehensive characterization of clinical radiation beams because the absorbed dose is a macroscopic average quantity, while the biological effects of particles are known to be related to the pattern of radiation interactions in the micrometric scale. DIODE (Diamond Integrated devices fOr haDronthErapy) project deals with the development and test of a novel detection system based on synthetic single crystal diamond able to simultaneously perform dosimetric and microdosimetric characterization of clinical hadron beams. Monte Carlo simulation plays a crucial role in the characterization of these devices. In particular, the Geant4 Monte Carlo toolkit, as it permits to predict response in terms of dosimetric and microdosimetric quantities such as dose to water, mean lineal energy and LET values. Through the comparison between the simulation with the experimental data acquired, it will be possible to understand limits and abilities of those new devices.

Ultra-thin silicon sensors for flash beams monitoring.

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Specifically designed for beam monitoring, the state-of-the-art gas ionization chambers exhibit non-linearity caused by saturation effects when exposed to ultra-high-dose-rate regimes (UHDR) of Flash Therapy. This innovative treatment approach can effectively reduce radiation damage to healthy tissues without compromising the antitumor effectiveness. However, the development of cutting-edge measuring systems is necessary to accurately monitor electron/proton Flash beams. At the Centro Pisano for Flash Radio Therapy (CPFR) where the SIT ElectronFlash Linac is installed, experiments were carried out to evaluate the performance of a 45 μm thick silicon sensor pad with an active area of 2 mm^2, reverse-biased with 200 V. The read-out is performed using an Application Specific Integrated Circuit (ASIC) called TERA08, which is a 64 channels current-to-pulse-frequency converter. With a 9 MeV electron beam and a pulse duration of 4 μs, the results show excellent linearity ($R^2 > 0.99$) up to the maximum achievable dose per pulse of 10 Gy/pulse, which corresponds to a charge of 600 nC/pulse collected on the silicon pad.

Development of a plastic scintillator-based detector for proton beam quality assurance.

Radogna R.
Università degli Studi di Bari "A. Moro", Dipartimento Interateneo di Fisica "M. Merlin"
Proton beam therapy provides significant clinical benefits over conventional X-ray radiotherapy. To ensure a safe treatment daily beam Quality Assurance (QA) checks are carried out each day before the treatment begins for the monitoring of beam parameters. Today, daily beam QA checks are time-consuming operations. Different measures are currently performed using different devices, with an average time spent for beam QA of about 40 minutes. To combine several QA checks and speed up the overall QA time, an integrated device is highly desirable. This work presents the design of a novel integrated detector able to measure simultaneously the beam range, spot position and size in one single beam delivery. The detector combines two independent modules, that is a range calorimeter and a scintillating fibres-based beam monitor. The new system allows for a direct measurement of the beam range and profile. To simulate the detector response a simulation in clinical conditions has been done using the Geant4 toolkit. Results from the simulation will be presented, together with the design and test of a first prototype for the novel detector.

Use of salicylic acid derivatives as Fe^{3+} chelating agents in Fricke gel dosimetry.

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Fricke gel (FG) dosimeters are based on chemical dosimeters in which radiation induced chemical reactions occur. Despite extensive research over the last three decades, FG dosimeters have yet to achieve widespread clinical acceptance, mainly because of some practical concerns. In particular, the reduction of spatial instability of dosimetric information is a major challenge. In this work, the well-known poly(vinyl-alcohol) (PVA)-based hydrogel was enriched by different salicylic acid derivatives as chelating agents for Fe^{3+}. The scope is providing the covalent functionalization of PVA with few steps and with high yield, with the

aim to reduce the ions diffusion. Among the chelating agents tested, only 4-aminosalicylic acid (4-ASA) appeared suitable for both dosimetric application and covalent functionalization of the polymeric matrix. The dosimetric characterization was performed by using 4-ASA in solution and linked to the PVA-matrix and irradiating the gel samples with x-rays generated by a LINAC. A successful development of such dosimetric materials would also lead to implementation of their use in a clinical practice.

▲ **Second-harmonic generation study of collagen irradiated scaffolds.**

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3D culture models are expected to introduce substantial advantages over cell monolayers because they open up the possibility of shifting radiobiological investigations from studies of cellular targets to the investigation of more complex cellular responses involving the network of signals arising from cell-cell and cell-matrix interactions. The first unavoidable step is to understand the radiation effects on the 3D scaffolds which could be used to culture cells. We start to investigate as possible 3D substrates the BIOPADTM and HyCo collagen pads used in bioengineering. These "sponges" are formed of native equine collagen that retains its triple helix structure allowing visualization of second harmonic generated. Results on scaffolds irradiated with protons and electrons will be presented. The irradiations are conducted in conventional and in ultra high dose rate, above 100 Gy/s, (FLASH) modalities.

● **Radioterapia e CD-44 in cellule tumorali di mammella.**

Mottareale R. (1), La Verde G. (1), Panzetta V. (2), Netti P. (2), Arrichiello C. (3), Muto P. (3), Pugliese M. (1)

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Gli effetti dovuti all'esposizione a radiazioni ionizzanti sono noti e utilizzati nella pratica clinica per il trattamento dei tumori in radioterapia. Tuttavia, è sempre più crescente l'interesse scientifico per la meccanobiologia responsabile della risposta cellulare alla terapia (ad es. radioresistenza). Studi recenti hanno confermato il ruolo delle radiazioni ionizzanti nelle alterazioni del citoscheletro e della matrice extracellulare, che sono coinvolti in processi di *spreading*, migrazione ed espressione delle proteine. Questo lavoro ha investigato l'espressione del recettore di membrana CD-44 utilizzando due linee cellulari di mammella MCF10A e MDA-MB-231 seminate su substrati in poliacrilamide di differenti rigidezze che mimano la matrice extracellulare sana e tumorale. L'espressione di CD-44 è stata poi valutata su campioni esposti a due dosi di irraggiamento, 2 e 10 Gy (utilizzate nei trattamenti radioterapici), per due diversi tempi post-esposizione (24 h e 72 h). L'analisi è stata condotta considerando l'espressione di CD-44, acquisita per immunofluorescenza, in rapporto alla superficie cellulare a valle di una ricostruzione 3D del campione tramite Imaris3D.

Studio dell'interfractional monitoring 3d con il dose profiler nel trial clinico del CNAO.

Lampertico L. ([1]), INSIDE Collaboration ([2])([3])
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Uno dei campi di ricerca nell'adroterapia è la misura sperimentale del profilo di dose per valutare la conformità della dose erogata con il trattamento pianificato. Il progetto INSIDE ha sviluppato un detector, il Dose Profiler, che misura le distribuzioni tridimensionali dell'emissione dei frammenti carichi secondari correlate alla morfologia del paziente nei trattamenti con ioni ^{12}C. Il detector è installato al CNAO (Pavia) e sta iniziando la seconda fase di un trial clinico. I risultati iniziali hanno mostrato la capacità del Dose Profiler di rilevare le differenze di dose erogate e pianificate dovute a cambiamenti morfologici interni ai pazienti tra una frazione e l'altra (*inter-fractional monitoring*), sfruttando il test del *gamma index*. In alcuni casi, le differenze sono state tali da richiedere la ripianificazione del trattamento. Nella presentazione saranno mostrati i metodi ed i risultati dell'ottimizzazione dei parametri del test del *gamma index* condotto su tutti i pazienti coinvolti nel trial clinico. Inoltre, è stata quantificata la sensibilità del Dose Profiler e della precisione del metodo nella misura delle eventuali variazioni morfologiche dei pazienti.

SYNCT: PET-driven SYNthetic control CT generation for treatment monitoring in proton therapy.

Moglioni M. ([1])([2]), Carra P. ([1])([2]), Belcari N. ([1])([2]), Bersani D. ([2]), Bisogni M.G. ([1])([2]), Ciocca M. ([3]), Ferrero V. ([4]), Fiorina E. ([1])([2]), Kraan A. ([2]), Morrocchi M. ([1])([2]), Pennazio F. ([4]), Retico A. ([1])([2]), Vitolo V. ([3]), Sportelli G. ([1])([2])([1])
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([3]) *CNAO*
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Proton therapy (PT) offers tumours treatments with highly conformal depth-dose distributions and less damage nearby healthy tissues over photon beam therapy. However, PT is sensitive to patient-specific anatomical variations which may lead to severe dose deviations. A control CT is generally prescribed to check the patient morphology. Treatment verification systems such as in-beam Positron Emission Tomography (IB-PET) are desirable to avoid the delayed detection of anatomical variations during PT treatments. However, the interpretation of the PET monitoring data is still a subject of research since PET does not offer a direct representation of the disease progress as a control CT does. The SYNCT project aims to overcome this issue by using Neural Networks (NN) to produce synthetic control CT (sCT) images which can provide a non-invasive and interpretable picture of the anatomical variations in the patients. We studied the feasibility of sCT production with MC simulations. The output of our NN, a Visual Transformer, correctly produced the sCTs, which were compared with the ground truth across multiple metrics of similarity. This work can be a highly valuable tool in adaptive PT.

Aula F5 - Hildred Blewett **ore 09:00 – 13:30**

Sezione VI
Fisica applicata, acceleratori e beni culturali
Presiede: Mascali D. (INFN, Laboratori Nazionali del Sud, CSFNSM e Università di Catania)

Relazioni su invito

▲ **Vittorio Vaccaro legacy: The impedance and collective effect in modern accelerators.**
Palumbo L.
Dipartimento di Scienze di Base e Applicate per l'Ingegneria, Università di Roma La Sapienza
Vittorio Vaccaro began his activity at CERN in 1966 as an electronic engineer in the RF group. It was the year in which construction of the ISR (Intersecting Storage Ring) accelerator started, it was the first hadron collider in the world, which went into operation in 1971. The machine was made of two intersecting rings, and to reach a high luminosity it was necessary to store a high current of protons beyond the then-known stability limits of the accumulated beams. In November 1966, Vittorio wrote the internal report "Longitudinal instability of a coasting beam above transition, due to the action of lumped discontinuities". In February 1967, together with Andrew Sessler, he presented a more general treatment in the CERN Yellow Report, "Longitudinal instabilities of azimuthally uniform beams in circular vacuum chambers of arbitrary electrical properties". In 1969, with Kurt Hubner and Alessandro Ruggiero, he extended his research to transverse instabilities in the article "Stability of the coherent transverse motion of a coasting beam for realistic distribution functions and any given coupling with its environment". In a few years, with these works, Vittorio Vaccaro laid the foundations of a solid theory for the study of instabilities in a storage ring. Using Vlasov's equation, he obtained the dispersion relationship in terms of quantity, which he defined as the "Coupling Impedance", which accounts for the electromagnetic interaction of the particle beam with the vacuum chamber and with the surrounding devices installed on the machine. Regarding these studies, Simon Van de Meer, Nobel Prize, stated: "The stream of this research, born at CERN and still lasting, gave and gives results that have been of great importance for the ISR project and for particle accelerator in general". Indeed, these works were the beginning of many studies which have taken place in the last fifty years; impedance and wake fields continue to be an important field of activity in theory, simulations, and particle beam measurements. Building a reliable impedance model for a machine is today the first step necessary to evaluate the performance limits of circular accelerators, used as colliders and synchrotron radiation sources, as well as of linear accelerators.

▲ **Betatron radiation: The EuAPS PNRR project.**
Curcio A. ([1]), Anania M.P. ([1]), Assmann R. ([1]), Avaldi L. ([5]), Balerna A. ([1]), Biagioni A. ([1]), Bolognesi P. ([5]), Chiadroni E. ([2]), Chiarinelli J. ([5]), Cianchi A. ([3]), Cirrone P. ([4]), Costa G. ([1]), Crincoli L. ([1]), Del Dotto A. ([1]), Del Giorno M. ([1]), Embrahimpour Z. ([1]), Falone A. ([1]), Francescone D. ([2]), Frazzitta A. ([2]), Galletti M. ([3]), Ghigo A. ([1]), Giannessi L. ([1]), Giribono A. ([1]), Gizzi L. ([6]), Labate L. ([6]), Mostacci A. ([2]), Opromolla M. ([1]), Petrillo V. ([7]), Petringa G. ([4]), Pompili R. ([1]), Romeo S. ([1]), Rossi A.R. ([7]), Stellato F. ([3]), Stocchi F. ([3]), Vaccarezza C. ([1]), Ferrario M. ([1])
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The EuPRAXIA Advanced Photon Sources (EuAPS) project, led by INFN in collaboration with the CNR and the University of Tor Vergata, involves the construction of a laser-driven "betatron" X-ray user facility at the SPARC_LAB laboratory of the LNF. EuAPS also includes the development of high power (up to 1 PW at LNS) and high repetition frequency (up to 100 Hz at CNR Pisa) laser drives for EuPRAXIA. In this communication we first examine the physics behind the dynamics of accelerated electron betatrons in plasma accelerator cavities: the betatron oscillations of relativistic electrons at very short scale lengths are responsible for the emission of ultrashort X-ray bursts. Next, we present the current status of the experimental activity at the LNF, finally discussing the relevant results for the EuAPS project, highlighting the expected performance of the source for user applications.

▲ **Low-emittance synchrotron light source: ALBA-II project.**
Benedetti G.
ALBA Synchrotron, CELLS
ALBA is a third-generation light source operated for external users since 2012 in Barcelona, Spain. With an electron beam emittance of 4.5 nm $\cdot$ rad at an energy of 3 GeV, it has started a series of studies for an upgrade to a diffraction limited soft X-rays storage ring that calls for an emittance smaller than 200 pm $*$ rad in a 269 m circumference. The ring of ALBA-II has to fit the existing tunnel and preserve the positions of the insertion device beamlines. In this communication we report on the design and performances of the future low-emittance lattice, based on a six-bend achromat cell with reverse dipoles and distributed chromatic correction.

Comunicazioni

● **Beam dynamics optimization of the EuPRAXIA@SPARC_LAB RF injector.**
Silvi. G.J ([1])([2]), Bacci A.L ([4]), Carillo M. ([1])([2]), Chiadroni E. ([1])([3]), Ferrario M. ([3]), Francescone D. ([1])([2]), Iovine P. ([1])([5]), Giribono A. ([3]), Mostacci A. ([1])([2]), Faillace L. ([3]), Pompili R. ([3]), Rossetti Conti M. ([4]), Vaccarezza C. ([3])
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At EuPRAXIA@SPARC_LAB an X-ray FEL user facility is driven by a plasma accelerator in the particle-driven configuration where an ultra-relativistic beam, the driver, through a plasma generates a wake of charge density useful for accelerating a witness beam. The electron bunches are generated through the so-called comb technique in an RF injector that consists of a 1.6 cell S-band gun followed by four S-band TW accelerating structures. The main working point foresees a 30 pC witness and a 200 pC driver longitudinally compressed in the first accelerating structure operated in the velocity-bunching regime, that allows to accelerate and manipulate the beam to reach proper transverse and longitudinal parameters. The optimization of the witness emittance is performed with additional magnetic field around the gun and the velocity bunching S-band structures and by shaping the laser pulse at the cathode. The paper reports on beam dynamics studies performed also with the insertion of

an X-band RF cavity after the gun that is proposed to shape the beam current distribution and stabilize it with respect to RF jitters.

Beam dynamics optimization for high-gradient beam-driven plasma wake field acceleration at SPARC_LAB.

Carillo M., Chiadroni E., Francescone D., Mostacci A., Silvi G.J., Alesini D., Anania M.P., Behtouei M., Bellaveglia M., Biagioni A., Crincoli L., Del Dotto A., Del Giorno M., Costa G., Giannessi L., Giribono A., Iovine P., Petrillo V., Di Pirro G., Pompili R., Romeo S., Shpakov V., Vaccarezza C., Villa F., Cianchi A., Galletti M., Parise G., Rossi A.R., Ferrario. M.
Sapienza, University of Rome

The SPARC_LAB test facility at the LNF (Laboratori Nazionali di Frascati, Rome) holds a high brightness photo-injector used to investigate advanced beam manipulation techniques. High-brightness electron bunch trains (so-called comb beams) can be generated striking on the photo-cathode of a Radio Frequency (RF) photo-injector with a ultra-short UV laser pulse train in tandem with the velocity bunching technique. Beam dynamics studies have been performed with the aim of optimizing the dynamics of the double beam (driver and witness) used to perform particle-driven plasma wake field acceleration (PWFA). In this scenario different scans on beam parameters were carried on adopting the ASTRA simulation code, to optimize the witness beam quality and improve the plasma booster stage performances. A benchmark of the simulations has been then performed, reproducing the experimental data obtained from the optimization of machine performances, and a good agreement was found.

On the betatron radiation in cylindrically symmetric plasma-ion channels.

Francescone D.
University of Rome "Sapienza"

The relativistic interaction of short pulsed lasers or electrons with plasma has recently led to the birth of a new generation of femtosecond X-ray sources. Radiations with properties similar to those that can be observed from a wiggler or undulator, can be generated by the oscillations induced in the excited plasma by electrons (PWFA) or by lasers (LWFA), making plasma an interesting medium both for the acceleration as well as for the radiation source, with properties of being compact, providing collimated, incoherent, femtosecond radiation. Thus, a lot of effort is being made to understand and improve this new source to make it really competitive, This paper summarizes and shows some theoretical results and numerical simulations of a simplified model called plasma ion column, using as a starting point the parameters expected for the EuPRAXIA@SPARC_LAB facility, highlighting strengths, limitations and scaling laws, which allow for a comparison with other types of more consolidated sources of light such as Compton, Synchrotron and Free Electron Lasers (FEL).

Photoluminescent colour centres in lithium fluoride film imaging detectors for monochromatic hard X-rays.

Vincenti M.A. ([1]), Montereali R.M. ([1]), Nichelatti E. ([2]), Nigro V. ([1]), Piccinini M. ([1]), Koenig M. ([3]), Mabey P. ([3]), Rigon G. ([3]), Albertazzi B. ([3]), Benkadoum Y. ([3]), Pikuz T. ([4]), Ozaki N. ([5]), Filippov E.D. ([6]), Makarov S. ([6]), Pikuz S. ([6])
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High spatial resolution X-ray diagnostic techniques such as X-ray microscopy, diffraction and phase-contrast imaging have important applications in various experimental fields. In recent years, LiF film detectors, based on optical reading of visible photoluminescence (PL) emitted by stable radiation-induced colour centres, are extensively used as X-ray imaging detectors because of their promising properties such as very high intrinsic spatial resolution over a large field of view, wide dynamic range and simplicity of use. Optically transparent polycrystalline LiF films (thicknesses of 0.5, 1.1 and 1.8 μm) were grown by thermal evaporation on Suprasil®, glass and Si(100) substrates at ENEA C.R. Frascati. They were irradiated at several doses with a monochromatic 7 keV X-ray beam at the METROLOGIE beamline of the SOLEIL synchrotron. After irradiation, their PL response, carefully investigated by using a fluorescence microscope, showed a linear behaviour as a function of the irradiation dose. Edge-enhancement imaging experiments, performed by interposing an Au mesh, 400 lpi, at a distance of 15 mm from the samples, allowed estimating a spatial resolution of (0.38 ± 0.05) μm.

Machine-detector interface for the 3 TeV muon collider.

Castelli L. ([1]), Collamati F. ([2]), Lucchesi D. ([3]), Zuliani D. ([3]), Sestini L. ([4]), Casarsa M. ([5])
([1]) *Università e INFN di Roma La Sapienza*
([2]) *INFN, Sezione di Roma1*
([3]) *Università e INFN di Padova*
([4]) *INFN, Sezione di Padova*
([5]) *INFN, Sezione di Trieste*
Muon collisions are considered a promising mean for exploring the energy frontier, leading to a detailed study of the possible feasibility issues. Beam intensities of the order of 10^{12} muons per bunch are needed to achieve the necessary luminosity, generating a high flux of secondary and tertiary particles that reach both the machine elements and the detector region. A strategy to reduce the beam-induced background to manageable levels at 3 TeV center-of-mass energy will be discussed. The configuration of the interaction region will be presented with particular focus on the absorber design, as well as the overall background-mitigation strategy with the relevant detector parameters in mind.

Tracking studies for the FCC-ee collimation system design.

Broggi G. ([1])([2])([3]), Abramov A. ([1]), Boscolo M. ([3]), Bruce R. ([1])
([1]) *CERN, Meyrin, Switzerland*
([2]) *Sapienza University of Rome, Rome, Italy*
([3]) *INFN-LNF, Frascati, Italy*
The Future Circular Collider (FCC) is a design study for a staged circular collider with a circumference of about 90 km, consisting of a luminosity-frontier, highest-energy electron-positron collider (FCC-ee) followed by an energy-frontier hadron collider (FCC-hh). The FCC-ee is being designed for stored beam energies up to 17.8 MJ, a value almost two orders of magnitude higher than any previous lepton collider. Considering the risk of any beam losses causing experimental backgrounds, magnet quenches, or even damage, a halo collimation system is under study to protect the most sensitive equipment from unavoidable losses. Beam dynamics and tracking studies are key aspects to evaluate the cleaning performance of the collimation system, and are essential in an iterative process to converge on an optimum

performance. The first results of such studies are presented, including estimated beam loss and power load distributions around the ring, with a particular focus on the Interaction Regions (IRs).

The Frascati Beam Test Facility.

Di Giulio C., Buonomo B., Foggetta L.G., Di Giovenale D., Cardelli F.
Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Frascati, Frascati, RM, Italia

In the development of the detectors for the high energy physics (HEP) and astro-particles physics, the test beam and irradiation facilities are the key enabling infrastructures. From 2005 the Beam Test Facility (BTF) of the DAΦNE accelerator complex in the Frascati laboratory of the Italian National Institute of Nuclear Physics (INFN) has gained an important role in the European infrastructures devoted to the development and testing of particle detectors and at the same time the BTF operation has been largely shadowed, in terms of resources, by the running of the DAΦNE electron-positron collider. A description of the status of the facility and on the beam lines features will be discussed.

Particle accelerators and gravitational waves: Challenges and possible synergies.

Petracca S. ([1]), Pinto I.M. ([2])
([1]) *Department of Engineering, University of Sannio, Benevento, Italy*
([2]) *Retired professor, University of Naples "Federico II", INFN e Optica, OSA, Fellow*

The milestone achievements represented by the first direct detection of gravitational waves of cosmic origin, and the observation of the Higgs boson, prompted particle accelerator and gravitational wave physicists to new challenges. Yet, on the one hand, jumping to the next level of collider energy/luminosity is not behind the corner; and, on the other hand, a largest fraction of the gravitational wave spectrum remains unaccessible to existing and planned gravitational wave detectors. Recently, studies of particle accelerators as possible sources/detectors of gravitational waves in yet unprobed spectral ranges, and of the impact of related technological advances (in particular in the field of magnets and superconducting resonators) on the performance of proposed gravitational wave experiments based on graviton/photon (Gertsenshtein) conversion, resurged —as witnessed by recent topical meetings hosted by CERN and ICTP. Some of the proposed new ideas will be reviewed/discussed.

Surface studies on a-Carbon coating of interest for future accelerators.

Angelucci M. ([1]), Spallino L. ([1]), Cimino R. ([1]), Hetzel C. ([2]), Verdu Andres S. ([2]), Weiss D. ([2])
([1]) *LNF-INFN, Frascati, Rome, Italy*
([2]) *Brookhaven National Laboratory, Upton, NY, USA*

Electron cloud (EC) will play a crucial role in the realization of the new generation of accelerators like the future Electron Ion Collider (EIC) in the US. Different solutions have been proposed to mitigate detrimental EC effects, as the use of a-Carbon coatings to reduce the secondaries emission from the surface. Coatings' secondary emission properties are not only intrinsic to structural, chemical and morphological characteristics of the surface, but also to the residual gas physisorbed on the walls and to the many interactions such surfaces will undergo during operation. Here we present the ongoing activity carried out the Material Surface Science Laboratory at LNF-INFN, focusing on the qualification and definition of the surface properties of interest for the hadron ring vacuum chamber.

Study of photoemission microscopy of single-photon detectors and topological materials.

Azizinia M., Gunnella R., Rezvani S.J.
Università di Camerino, Divisione di Fisica, Camerino, Italy

In the present study, Scanning X-ray Photoelectron Spectromicroscopy (SPEM) has been employed to investigate the chemical and elemental distribution of Bi_2Se_3 samples at submicron scale, providing valuable insights into their properties. The aim of this research work is to examine how the quality of the thin films including thickness, composition, and uniformity relates to their growth conditions, and to investigate the role of substrates in physical process. The study presents the results of three deposition sessions conducted at different times on various substrates, namely Pt-patterned Si, Au-patterned Si substrates and borosilicate glass. The stoichiometry of the grown films has been found to be different in the case of growth on different substrates. Further, the effects of defects and impurities present on the Bi_2Se_3 thin film has been investigated, being important in order to understand the materials' stability and potential for practical applications. The results show different degrees of oxidation in Bi_2Se_3 thin films that could be correlated with the initial conditions of the procedure, regarding temperature and gas flow/vacuum conditions in production process.

Microwave-matter interaction for enhanced carbon capture by mineral carbonation.

Yivlialin R. ([3]), Campione M. ([1]), Corti M. ([1]), Capitani G. ([1]), Lucotti A. ([2]), Tommasini M. ([2]), Bussetti G. ([3])([1]), Malaspina N. ([1])
([1]) *Dipartimento di Scienze dell'Ambiente e della Terra, Università degli Studi di Milano-Bicocca, Milano, Italy*
([2]) *Dipartimento di Chimica, Materiali e Ingegneria Chimica, Politecnico di Milano, Milano, Italy*
([3]) *Dipartimento di Fisica, Politecnico di Milano, Milano, Italy*

The formation of stable and insoluble Mg- and Ca-carbonates and/or hydroxy-carbonate hydrates, through water-mediated reaction of $Mg(OH)_2$ (brucite) and $Ca(OH)_2$ (portlandite) with carbon dioxide, is referred to as mineral carbonation (MC). MC is among the most promising potential solutions for long-term carbon capture and storage (CCS), since it is spontaneous under a wide range of conditions. However, kinetic barriers pose severe limitations to the practical exploitation of MC, implying energy requirements to reach sufficiently high reaction rates. Trying to overcome these hindrances, we show here the application of microwave (MW)-assisted processes for the carbonation of brucite, used as a model system for the carbonation occurring in a number of widely diffused minerals, such as serpentine. The mechanism, kinetics, and energy costs of the reaction, together with the chemical characteristics of the products obtained, are inferred by a combined study, carried out by both a MW synthesizer on bulk brucite water slurries and a purposedly developed microscopy platform, working on nano-scale regions of the surface of brucite single crystals.

Rogowski coil: Pulsed beam current diagnostic at extremes.

Nassisi V. ([1])([2]), Accoto G. ([1]), Buccolieri G. ([1]), Monteduro L. ([1]), Paladini F. ([1])
([1]) *Department of Mathematics and Physics, LEAS Laboratory, University of Salento, INFN, Sect. Lecce*
([2]) *Department of Biological and Environmental Sciences and Technologies, University of Salento, Lecce*

Short current pulses are increasingly prevalent in electronics devices such as accelerator machines, digital communication, electromagnetic pulse generators and others. Rogowski coil detectors are used to monitor them in order to know the intensity and temporal behaviour.

Currently, electromagnetic stresses in biological samples are applied by linear transmission line, and as a consequence Rogowski coils by linear structure are developed. The last developments have exhibited response rise time increased of more 100 ps *vs.* an input pulse by rise time of about 250 ps. Clearly, measurements with faster rise times would be more appropriate and for this reason appropriate homemade probes have been made. The input pulse was generated by a 50 Ω coaxial line 2 m long by a fast switch (Reed relay h12). Two different Rogowski coils were done and compared, by 210 and 22 rings, whose capacitance values *vs.* ground and between ring and ring, were different. The capacitance values resulted lower for the 22-turns coil. With this Rogowski coil the rise time of the response was only slightly higher, by 50 ps, than the input one.

Aula F2 - Ginestra Giovene Amaldi **ore 09:00 – 13:30**

Sezione VII
Didattica e storia della fisica
Presiede: Mantovani R. (Università di Urbino)

Relazioni su invito

▲ **La prima misura della carica dell'elettrone.**
Robotti N. ([3])([4]), Leone M. ([1])([4])([5]), Monti F. ([2])([4])
([1]) *Dipartimento di Filosofia e Scienze dell'Educazione, Università di Torino, Torino, Italia*
([2]) *Dipartimento di Informatica, Università di Verona, Verona, Italia*
([3]) *Dipartimento di Fisica, Università di Genova, Genova, Italia*
([4]) *Centro Ricerche Enrico Fermi - CREF, Roma, Italia*
([5]) *INFN Sezione di Torino, Torino, Italia*
In merito alla scoperta dell'elettrone, solitamente vengono citati come esperimenti fondamentali quello di J.J. Thomson del 1897 sulla misura del rapporto massa/carica e quello di R. Millikan del 1911 sulla misura della carica. Al fine di riempire il vuoto di oltre 14 anni tra questi due esperimenti, abbiamo ricostruito le ricerche condotte da un lato da Thomson dal 1897 al 1903, quando cessa di occuparsi di questo argomento, e dall'altro lato da Millikan a partire dal 1907, quando si impegna in una misura la più precisa possibile della "carica unitaria", già introdotta a fine Ottocento per spiegare il legame chimico. Da questa analisi emerge che l'esperimento di Millikan del 1911 non è stato il completamento naturale di quello di Thomson del 1897. È infatti Thomson che già nel 1899 ha misurato per primo, con un esperimento sull'effetto fotoelettrico purtroppo dimenticato, la carica dell'elettrone. A Millikan va invece il merito di aver dimostrato che tutte le cariche sono multipli interi della "carica unitaria" e che questa carica è quella dell'elettrone. Come evidenzieremo, questo chiarimento a livello storico può avere implicazioni importanti di ordine didattico.

▲ **Gian Carlo Wick: l'anti-Majorana di Via Panisperna.**
Guerra F. ([1])([3]), Robotti N. ([2])([3])
([1]) *Dipartimento di Fisica, Università di Roma La Sapienza, Roma, Italia*
([2]) *Dipartimento di Fisica, Università di Genova, Genova, Italia*
([3]) *Centro Studi e Ricerche "Enrico Fermi", Roma, Italia*
Noi richiamiamo alcuni aspetti dell'attività scientifica e accademica di Gian Carlo Wick dopo il conseguimento della Laurea a Torino nel 1930, e i primi contatti indiretti con Via Panisperna nel 1931, passando per la sua assunzione ufficiale nel 1932, e le vicende del concorso per la cattedra di Fisica Teorica a Palermo nel 1937 e della chiamata a Palermo nel 1938. Mostriamo come in queste vicende ci sia un intreccio costante con Ettore Majorana. Noi utilizziamo nuovi documenti provenienti dagli Archivi dell'Università di Roma, dell'Università di Berkeley e dell'Università di Palermo e di Padova. Esistono elementi per credere che Ettore Majorana sarebbe stato interessato ad essere chiamato a Palermo, anche dopo essere stato nominato per chiara fama a Napoli, di fronte al tentativo di Padova di chiamare direttamente Wick, e alla riluttanza di Wick di andare a Palermo, nonostante la promessa fatta a Segrè. Analizzeremo anche la posizione assunta da Enrico Fermi, nel confronto con Emilio Segrè.

▲ **Edoardo Amaldi (1908-1989), Constance Dilworth (1924-2004) and Giuseppe Paolo Stanislao Occhialini (1907-1993) on Friedrich Georg Houtermans (1903-1966).**

Tucci P.
Università degli Studi di Milano, Milano, Italia

Houtermans was a German physicist who lived in a troubled period for the world history, experiencing Nazi wickedness and cruelty of Stalinian purges. A biography, written by Amaldi, was posthumously published in 2012. Three typed copies of Houtermans' biography are kept in the Dilworth-Occhialini Archives; Occhialini sketchily annotated the first one. He had met Houtermans in Cambridge in 1932 and in London in 1950 at G. Gamow's (1904-1968) home and at his/Dilworth's home. Dilworth spoke with Houtermans face to face while Occhialini had gone away. Following the London talks, both Occhialini and Dilworth were fully convinced of Houtermans' good faith. They were interested in the involvement of other physicists such as Heisenberg or Rosbaud under Nazi regime. While Amaldi's biography is fairly complete, Occhialini's and Dilworth's considerations are entrusted to manuscripts which capture only some aspects of Houtermans' personality. Nevertheless, it is possible to identify in the writings of the two Milanese physicists some features that distinguish them from Amaldi's reconstruction, despite the common intent of rehabilitating Houtermans from the suspicion of having been a Nazi spy.

▲ **Fred Hoyle e la legge di creazione dell'universo.**

Giannetto E.
Università di Bergamo, Bergamo, Italia

Nel 1948, Fred Hoyle propose come teoria alternativa al big bang una soluzione radicale che voleva evitare l'origine singolare dell'universo: l'origine stessa doveva essere la conseguenza di una legge naturale. L'origine della materia era da pensarsi nei termini dell'esistenza di un campo fisico-cosmico di creazione, C-field, a energia e pressione negative. Si dovevano modificare le equazioni di campo della relatività generale introducendo un nuovo termine in cui figurasse il campo di creazione: questo permetteva di soddisfare il cosiddetto "principio cosmologico perfetto", che postulava l'omogeneità e l'isotropia dell'universo non solo nello spazio, ma anche nel tempo. Si trattava sostanzialmente di garantire non solo l'eternità dell'universo, ma anche la sua identità strutturale, come densità costante delle galassie nel tempo: per quanto temporale e in espansione, l'universo non era realmente evolutivo. Mantenere costante nel tempo la densità delle galassie implicava una creazione continua di altra materia a un tasso temporale opportuno che compensasse il reciproco allontanamento delle galassie per l'espansione dell'universo.

Comunicazioni

● **Integrating physics and philosophy in teaching: Henri Poincaré and the critique of ontological commitment reconsidered.**

Fortino M.
Liceo Classico "Bernardino Telesio", Cosenza, Italia

Questioning the 19th-century claim of a clear separation between the natural sciences (Naturwissenschaften) and the spirit sciences (Geisteswissenschaften), with the proposed contribution we intend to argue for their close connection. In particular, we will highlight the value of the philosophical reflection of the Nancy physicist and mathematician Jules Henri Poincaré (1854-1912), professor at the Sorbonne and head of the conventionalist school in the French fin de siècle milieu. We will reconsider, with reference to certain passages of his texts, his critique of the ontological commitment, which in the 20th century gave rise to numerous

controversies on the truth value of physical theories. In this historical-critical context, we would like to emphasise how the teaching of physics and the teaching of philosophy, aimed at the cultural formation of young minds in the lyceum, can benefit from this critique insofar as it can be conceived as an antidote to a dogmatic conception of knowledge.

La scoperta delle "Lezioni di Chimica fisica a cura degli studenti Enrico Bovalini ed Enrico Fermi. Anno Accademico 1920-1921".

Bagni E.
Dipartimento di Economia e Management, Università di Pisa, Pisa, Italia

Enrico Fermi, allievo di Luigi Puccianti, l'11 dicembre 1919 scrisse ad Enrico Persico: "[...] tra le altre cose mi sono dato all'industria delle dispense". Da una ricerca dell'autore è emersa una dispensa universitaria relativa all'anno accademico 1920-1921 in Chimica fisica a cura degli studenti Enrico Fermi ed Enrico Bovalini. Detta dispensa sarà presentata al Congresso.

La relatività da Galilei a Einstein

Stabile A.
INFN Sezione di Napoli, Gruppo collegato di Salerno, Salerno, Italia

L'articolo ripercorre, mediante un approccio non tradizionale (assiomatico-deduttivo), l'evoluzione dei concetti di spazio e tempo dalla fisica newtoniana fino alla fisica relativistica. Questa presentazione fornisce elementi di riflessione sui concetti fondamentali —come sincronismo, simultaneità e causalità— sia per i cultori della materia che per i docenti coinvolti in un corso introduttivo di fisica relativistica nella scuola secondaria superiore di secondo grado.

L'esperienza di Millikan: semplicità concettuale e ricchezza didattica.

Marocchi D., Lacarbonara M., Rinaudo M., Serio M.
Dipartimento di Fisica, Università di Torino, Torino, Italia

Introdurre didatticamente nel mondo del non visibile è sempre un passo complesso per le difficoltà di visualizzazione mentale e di collegamento con le esperienze del mondo che ci circonda. Fa da sfondo, inoltre, l'idea che tutto il mondo del microscopico richieda leggi complesse e complicate. L'esperienza di Millikan, nella sua essenza, ha una semplicità concettuale che può essere compresa anche da studenti che hanno affrontato solo la fisica classica. Nello stesso tempo introduce nel mondo della fisica moderna e può essere vissuta come esperienza di laboratorio, applicazione di nuove metodologie, approccio storico alla didattica della fisica. L'esperienza condotta con studenti della scuola superiore ha permesso di sperimentare questi diversi passaggi che saranno presentati, cercando di coglierne gli aspetti essenziali e didatticamente formativi.

La mostra interattiva di Scienze "Sperimentare giocando, conoscere sperimentando".

Immé J. ([2]), Pennisi A. ([1]), Russo A. C. ([2])([3]), Greco A. ([1]), Lizzio M. L. ([2]), Nicosia G. ([2])
([1]) *AIF, Sezione di Giarre-Riposto, Catania, Italia*
([2]) *AIF, Sezione di Catania, Catania, Italia*
([3]) *Liceo scientifico "Principe Umberto", Catania, Italia*

La mostra "Sperimentare giocando, conoscere sperimentando", dopo due edizioni online a causa della pandemia, è ritornata finalmente in presenza con l'ottava edizione svolta in due tappe, a Giarre e per la prima volta a Catania, promossa dalle sezioni AIF delle due città, con il supporto di alcuni enti patrocinatori. Come nelle precedenti edizioni, gli exhibit della

mostra sono esperimenti scientifici ideati, realizzati e presentati dagli stessi studenti della scuola secondaria, con la supervisione dei loro insegnanti. Le due tappe della mostra hanno riscosso un notevole successo, con migliaia di studenti visitatori veramente interessati, anche grazie all'abilità, competenza ed entusiasmo degli studenti espositori. In questa edizione per alcuni exhibit sono stati coinvolti anche studenti universitari. Il successo della mostra è testimonianza di come l'apprendimento in un contesto informale, realizzato con questa modalità di forte coinvolgimento, sia veramente efficace sia per gli studenti che espongono che per quelli in visita, ma anche per i docenti accompagnatori che hanno apprezzato la qualità e la cura degli exhibit, che spesso si sono rivelati ispiratori di attività in classe.

The IYPT 2019 celebrated in Latina (Italy).

Bonacci E.

Natural Sciences Unit, ATINER, Athens, Greece

We illustrate the International Year of the Periodic Table 2019 celebrated in Latina (Italy) under the UNESCO aegis. The IYPT19 was hosted by the Scientific High School G.B. Grassi of Latina, venue of the Planetarium Livio Gratton, with scientific lectures, topical talks, astronomical shows, and artistic performances. Co-organizers of the event were the UNESCO Club of Latina, the Photographic Association RiScatto, the Latina's Section of the Italian Philosophical Society (Feronia), the Luogo Arte Music Academy (LAAM) and the Sermoneta's Association of Civil Protection (A.P.C. Sermoneta O.N.L.U.S.). Keynote speaker was Dr. Chiara Salvitti from La Sapienza University of Rome.

The Italian Summer Students Program at Fermi National Accelerator Laboratory: 40 years of education for physics and engineering students.

Donati S., Barzi E., Bellettini G.

INFN, Sezione di Pisa e Fermi National Accelerator Laboratory, Università di Pisa, Pisa, Italy

Since 1983 the Italian groups collaborating with Fermilab have been running a 2-month summer training program for Master students in physics and engineering. The program has involved almost 600 Italian students from more than 20 Italian universities. Each intern is supervised by a Fermilab Mentor responsible for the training program. Training programs spanned from Tevatron, CMS, Muon $(g-2)$, Mu2e and SBN and DUNE design and data analysis, development of detectors, design of electronic and accelerator components, infrastructures and software for tera-data handling, quantum computing and research on superconductive elements and accelerating cavities. In 2015 the University of Pisa included the program within its own educational programs. Students are enrolled at the University of Pisa for the duration of the internship and are required to write summary reports on their achievements. After positive evaluation by an Examining Board, interns are acknowledged 6 ECTS credits for their Diploma Supplement. In 2020 and 2021 the program was canceled due to the emergency but in 2022 was restarted and trained 21 students. We are now organizing the 2023 program.

Fisica e scuola secondaria di primo grado: ingombrante presenza o grande assente?

Sottili L.

I.C. Borgo San Lorenzo, Borgo San Lorenzo, FI, Italia

Lo studio della fisica all'Università è un punto di inizio per la carriera scientifica di ogni studente, ma anche il punto conclusivo di un percorso di studi che comincia più di una decade prima dell'immatricolazione. Molte attività sono oggi dedicate, da parte dei vari dipartimenti, alla divulgazione e all'orientamento degli studenti delle scuole "superiori",

mentre meno numerosi sono i contatti tra gli addetti del settore e gli ordini "inferiori" di istruzione. Questo contributo si pone l'obiettivo di porre al centro della discussione il ruolo della fisica nell'insegnamento delle scienze "naturali" nella scuola secondaria di primo grado tra normative vigenti, letteratura scolastica, e formazione universitaria degli insegnanti.

Aula P2 **ore 09:00 – 13:30**

Sezione Giovani
Presiedono: Vismara M. (AISF)
Ostinato M. (Progetto Young Minds, EPS)

La sesta edizione della Sezione Giovani avrà come tema portante la Carriera e i modi in cui si può sviluppare dopo un percorso di studi in Fisica. Lo scopo è fornire conoscenze e strumenti utili a prendere decisioni lavorative ragionate così da poter indirizzare la propria carriera in maniera informata. Si tratteranno temi trasversali come il trasferimento tecnologico, il rapporto con il mondo dell'industria e quali siano i meccanismi tramite cui enti pubblici e privati erogano finanziamenti.

Relazioni su invito

▲ **L'Europa è amica dei giovani.**
Ferroni F.
GSSI, Scuola Universitaria Superiore Gran Sasso Science Institute
La Ricerca in ambito internazionale, le sfide poste da progetti complessi agli Enti di Ricerca nazionali, il ruolo dell'Europa nel mettere ordine ai processi di aggregazione ad alto livello e allo stesso tempo nel promuovere la crescita dei giovani ricercatori per aiutarli a trovare un ruolo di leadership. Tra successi e criticità.

▲ **Il fisico nel mondo della ricerca... e non solo!**
Mattone C.
CAEN S.p.A.
Corso di laurea e dottorato in Fisica hanno l'obiettivo di impartire agli studenti una formazione in fisica di livello professionale. È consuetudine pensare che, dopo gli studi, il giovane fisico possa intraprendere solo l'attività di ricerca o di insegnamento e/o diffusione della cultura scientifica. In realtà le possibilità di lavoro sono più variegate di quanto si pensi ed il ruolo del fisico risulta molto appetibile sia dal settore pubblico che da quello industriale. Durante gli studi si sviluppano infatti capacità di problem solving, competenze e duttilità tali che il fisico si inserisca facilmente in contesti lavorativi quali, ad esempio, produzione e studio delle proprietà di nuovi materiali, prevenzione e controllo dei rischi ambientali, analisi nel campo dei beni culturali, analisi del rischio sismico, analisi bancarie, tecniche per la fisica dell'atmosfera, progettazione test ed utilizzo di sistemi di rivelatori e di sensori, progettazione elettronica, dosimetria delle radiazioni ionizzanti e non ionizzanti in ambito medico ed ambientale, fisica medica e sanitaria nell'ambito della prevenzione, diagnosi e cura e nella radioprotezione personale ed ambientale.

▲ **L'importanza del trasferimento tecnologico nella ricerca scientifica: Impatti economici, protezione della proprietà intellettuale e opportunità di carriera nell'industria.**
Mollo C.M.
INFN, Sezione di Napoli
Il trasferimento tecnologico riveste un ruolo fondamentale nel mondo della ricerca scientifica, facilitando la transizione dei risultati della ricerca verso l'industria e la società. La

protezione della proprietà intellettuale è un elemento cruciale. I ricercatori devono garantire che le loro scoperte siano adeguatamente protette attraverso brevetti, copyright e altre forme di protezione, al fine di sfruttare economicamente i risultati della loro ricerca. Ciò promuove l'innovazione, incoraggiando i ricercatori a cercare collaborazioni con l'industria. Le innovazioni tecnologiche derivanti dalla ricerca scientifica possono essere commercializzate. Questo crea opportunità di investimento, aumenta la competitività delle imprese e stimola la crescita economica. Inoltre, il trasferimento tecnologico può generare flussi di entrate attraverso il licensing e la creazione di spin-off promuovendo anche lo sviluppo di carriere multidisciplinari. In questo contributo verranno mostrati i principali meccanismi legati al trasferimento tecnologico, gli strumenti e le metodologie pratiche per far sì che un'idea possa trasformarsi in una impresa di successo.

Aula P1 **ore 14:30 – 15:10**

Sezione VI
Fisica applicata, acceleratori e beni culturali
Presiedono: Falciano S. (GSSI, L'Aquila)
Ghigo A. (INFN, Laboratori Nazionali di Frascati)

Relazione Generale

The rise of machine learning: Opportunities and challenges in physics.
Bonacorsi D.
Università di Bologna
The adoption of machine learning techniques has emerged as a powerful and pervasive tool in most scientific and industrial environments, revolutionising the way complex problems are attacked. The raise of ML in physics is having a deep impact in shaping its future, with its potential to accelerate scientific discoveries, uncover hidden relationships, optimise experimental designs, and more. In addition to discriminative AI, the raise of generative AI solutions has the potential to offer effective ways to simulate complex physical phenomena and generate realistic data for experimental and theoretical investigations. On the other side, physics poses unique challenges in terms of incorporation of domain knowledge, interpretability and explainability. Examples from the past and the present, as well as emerging approaches that harness ML to gain deeper insights and push the boundaries of our understanding of the universe, will be presented and discussed.

Aula F1 - Augusta Manfredini **ore 15:10 – 19:30**

Sezione I
Fisica nucleare e subnucleare
Presiedono: Cenci P. (INFN, Sezione di Perugia)
Piccinini F. (INFN, Sezione di Pavia)

Relazioni su invito

▲ **Stato e prospettive per la fisica del quark top a LHC.**
Dell'Asta L.
Dipartimento di Fisica, Università degli Studi di Milano e INFN, Sezione di Milano
Il quark top è la particella più pesante del Modello Standard. La grande quantità di dati raccolti dall'esperimento ATLAS all'LHC permette sia di effettuare misure di precisione riguardanti la produzione e le proprietà del quark top, sia di studiarne processi di produzione rari, mai osservati finora. La comunicazione illustrerà i risultati più recenti riguardanti la fisica del quark top dell'esperimento ATLAS con dati da collisioni protone-protone ad un'energia nel centro di massa di 13 TeV e con i nuovi dati a 13.6 TeV.

▲ **Stato dei nuovi rivelatori al Run 3 di LHC e futuri upgrade (ATLAS, CMS, LHCb).**
Venditti R. per le ATLAS, CMS, LHCb Collaborations
Università di Bari e INFN
Il terzo run di LHC, ora in corso, e i run futuri consentiranno di estendere il programma di fisica di ATLAS, CMS e LHCb. È stato dunque messo a punto un programma di upgrade degli apparati. Prima dell'inizio del Run 3 sono state installate nuove stazioni nel sistema a muoni di ATLAS e CMS; LHCb è stato ristrutturato con l'installazione di nuovi Vertex Locator, Upstream Tracker e tracciatore a Fibra Scintillante. La fase ad alta luminosità di LHC spingerà le sfide sperimentali al limite tecnologico per l'aumento del livello di radiazione e interazioni di pile-up: alta granularità, resistenza alla radiazione e precisione temporale spinta saranno fondamentali nei rivelatori per Run 4 e 5. Gli upgrade di ATLAS e CMS prevedono l'installazione di nuovi sistemi di tracciamento e stazioni nel sistema a muoni prima dell'inizio del Run 4. In CMS sarà installato un calorimetro ad alta granularità e un rivelatore di tempo di volo. L'apparato di LHCb sarà rinnovato prima del Run 5: Vertex Locator, tracciatore, RICH, calorimetro elettromagnetico e stazioni del sistema a muoni saranno sostituiti con sistemi basati su tecnologie all'avanguardia e sarà installato un rivelatore di tempo di volo.

Comunicazioni

● **Fisica del charm in CMS.**
Della Penna L.
Università di Perugia e INFN, Sezione di Perugia
La fisica del charm rappresenta un laboratorio molto interessante per indagare la Cromodinamica Quantistica (QCD). In un detector come CMS, che non è provvisto di un sistema specifico per l'identificazione delle particelle, la ricostruzione e l'identificazione di stati charmati risultano particolarmente impegnative. La prima misura di sezione d'urto di open charm

in CMS a $\sqrt{s} = 13$ TeV da collisioni protone-protone ha dimostrato la possibilità di superare tali difficoltà. In un prossimo futuro si ambisce ad ottenere una misura totale di sezione d'urto di quark charm in funzione dell'energia di centro di massa. A tale scopo, in questa comunicazione si presenterà la prima misura di sezione d'urto di open charm all'energia di centro di massa di 900 GeV, con dati raccolti da CMS durante la prima parte del Run3 (2021 e 2022).

Studio del candidato multiquark esotico $X(3872)$ con i primi dati raccolti dall'esperimento CMS durante il Run 3.

Palmeri N.
Università di Roma I e INFN, Sezione di Roma I

Questo contributo descrive lo studio della produzione del candidato multiquark esotico $X(3872)$ attraverso il decadimento di mesoni B neutri nei primi dati della Run 3 dell'esperimento CMS ad LHC, raccolti nel 2022. Determinare la branching fraction del processo con la massima precisione possibile è di importanza vitale per poter comprendere al meglio la sua struttura interna e i suoi meccanismi di produzione, a causa delle difficoltà teoriche legate alla QCD che emergono nello studio dell'$X(3872)$. In questo contesto, particolare attenzione è stata dedicata allo studio delle prestazioni di un nuovo trigger dimuonico a bassa massa introdotto nel Run 3 di LHC.

Data-driven performance of muon momentum scale at CMS using the Z boson mass as a standard candle.

Alexe C.A.
Università di Pisa e INFN, Sezione di Pisa

An essential ingredient for the physics program of the CMS experiment at the Large Hadron Collider (LHC) is the accurate measurement of the momentum of charged particles using the CMS Tracker. In this communication, we report on a data-driven study of the muon momentum scale at CMS using the Z boson mass as a standard candle. The study is performed using data from proton-proton collisions at 13 TeV, collected by the CMS detector during the LHC Run 2 period. The Z boson mass is reconstructed from pairs of muons with opposite charge and with an invariant mass near the world average measurement. We perform a fit of the Z boson peak position and width and extract the muon momentum scale correction factors due to correlated geometrical distortions, known as weak modes. The corrections due to weak modes are determined after the standard calibration and alignment of the tracks has been applied, thus a gain in the accuracy of the momentum scale is obtained as a result of the presented work. The improvement in momentum scale determination will enhance the precision of physics analyses performed at CMS, ranging from precision measurements such as the W mass to searching for new physics.

Accoppiamenti del bosone di Higgs nella produzione associata VH mediante il decadimento in due fotoni.

Ursini R.
Università di Roma I e INFN, Sezione di Roma I

Oggetto della presentazione è lo studio della violazione di simmetria *CP* nell'accoppiamento del bosone di Higgs con bosoni vettori deboli (HVV). I dati utilizzati nell'analisi sono stati raccolti dall'esperimento CMS durante l'intera Run 2 di LHC, corrispondente ad una luminosità integrata di 138 fb^{-1}, ad un'energia di collisione protone-protone di 13 TeV. Sono studiati gli effetti cinematici di tali accoppiamenti nel canale di decadimento dell'Higgs in due fotoni, e la sua produzione congiuntamente ad un bosone vettore debole, VH (V = W, Z), considerando tutti i possibili canali di decadimento del bosone vettore, sia adronici che leptonici (con elettroni o muoni nello stato finale). Al fine di valutare possibili effetti di nuova

fisica nel settore dell'Higgs, vengono considerate sia un'estensiva simulazione del detector con campioni Monte Carlo, sia algoritmi di analisi multivariata, con lo scopo di discriminare diversi meccanismi di produzione. La ricerca di possibili anomalie nell'accoppiamento dell'Higgs con i bosoni vettori è interpretata come un'estensione della Lagrangiana del Modello Standard nel contesto delle Teorie Effettive di Campo.

LFV nel decadimento di $\tau \to 3\mu$ all'esperimento CMS, con τ prodotti dal decadimento di mesoni B e D.

Buonsante M.
Università di Bari e INFN, Sezione di Bari

Il decadimento $\tau \to 3\mu$ è un processo che, violando il sapore leptonico (LFV), risulta fortemente soppresso nel modello standard (BR $\sim 10^{-56}$–10^{-53}). Lo studio di questo processo è quindi di particolare interesse per evidenziare eventuali contributi oltre il modello standard, che possono portare questo decadimento a valori anche di 10^{-10}–10^{-7}. L'analisi presentata considera eventi in cui il leptone τ è prodotto nel decadimento di mesoni D e B (HF). Questo canale è molto interessante, perché ad LHC la produzione di mesoni HF è particolarmente abbondante, garantendo quindi di integrare un'elevata statistica, ma, data la cinematica del processo, lo stato finale è caratterizzato da muoni di basso p_T ed alta pseudorapidità, richiedendo la massima efficienza ed accettanza. In questa comunicazione si presentano i risultati dell'analisi dei dati raccolti dall'esperimento CMS nel Run 2. Saranno inoltre descritte le strategie sviluppate per il Run 3 per ottimizzare l'efficienza dell'algoritmo di trigger dedicato a selezionare eventi per questo segnale e permettere di migliorare la sensitività dell'analisi.

Ricerca di Leptoquarks in collisioni leptone-quark ad LHC.

Foglietti A.
Università di Roma I e INFN, Sezione di Roma I

I Leptoquark (LQ) sono particelle esotiche, predette da teorie di nuova fisica oltre il Modello Standard, che presentano sia un numero barionico che leptonico e che si accoppiano a quark e leptoni. L'analisi proposta utilizza i dati raccolti in Run2 (2016–2018) per la ricerca di LQ attraverso un nuovo meccanismo di produzione. Esso prevede l'interazione tra un leptone (estratto da uno dei protoni del fascio) ed un quark (proveniente da un protone dell'altro fascio); a seguito di questa interazione è possibile studiare la produzione risonante (s-channel) di un LQ ed il suo relativo decadimento ($l + q \to \mathrm{LQ} \to l + q$). Lo stato finale comprende un jet ed un leptone carico di alto momento trasverso. L'analisi viene condotta tramite la ricerca un picco, corrispondente alla massa ignota del LQ, su un fondo esponenziale decrescente nello spettro di massa invariante del leptone e del jet ricostruito. Questa analisi mira ad estendere il potenziale di scoperta dei LQs per particelle di alta massa (> 1 TeV) e per valori grandi del coupling LQ-leptone-quark.

Legacy measurement of the Higgs boson mass with Run1 and Run2 pp collisions data collected by the ATLAS detector.

Nasella L.
Dipartimento di Fisica, Università degli Studi di Milano e INFN, Sezione di Milano, Italia

In this communication the latest Higgs boson mass measurements with the ATLAS detector are presented; the analyses use Run2 data from the Large Hadron Collider at a centre-of-mass energy of 13 TeV for a total integrated luminosity of 140 fb^{-1}. To measure the Higgs boson mass, the di-photon and four leptons channels are exploited as the invariant mass of the decay particles can be reconstructed by ATLAS with high precision. Firstly, the communication will focus on the mass measurement in the di-photon channel: the mass is

evaluated from the position of the narrow resonant peak in the di-photon invariant mass distribution over a large, monotonically decreasing, continuum background. The analysis exploits the most updated knowledge of the detector performance and calibrations and uses an event categorisation optimized to reduce the total uncertainty. Finally, the legacy ATLAS Higgs boson mass measurement is derived from a combined fit to the invariant mass spectra of the $\gamma\gamma$ and $4l$ decay channels, including also the Run1 data.

Measurements of Z boson production in association with heavy-flavour jets at ATLAS.

Bisceglie E., Schioppa M., Meoni E.
Università della Calabria e INFN Frascati, gruppo collegato di Cosenza

Measurements of Z-boson production in association with jets are an important test of perturbative QCD prediction and also provide information about the parton distribution functions of the proton. In this communication, we present the latest measurements of the production of a Z-boson in association with heavy-flavour jets performed using proton-proton collision data collected by the ATLAS experiment between 2015 and 2018 at $\sqrt{s} = 13$ TeV corresponding to an integrated luminosity of 139 fb^{-1}. This includes inclusive and differential cross-section measurements up to extreme phase spaces characterized by high-transverse-momentum jets. The data are compared to predictions provided by the state-of-the-art Monte Carlo event generators.

Performance of the muon object during the 2022 data-taking period of CMS.

Bhattacharya R.
Università di Pisa e INFN, Sezione di Pisa

The Compact Muon Solenoid (CMS) detector is one of the two multi-purpose detectors at the Large Hadron Collider (LHC) and as such, has a broad physics program. Some of the key aspects for the success of the physics program are the triggering, reconstruction, identification, and calibration of muons over a wide range of momenta. Muons are reconstructed in CMS combining the information from the tracker detector and dedicated muon chambers placed inside the magnetic return yoke. Identification algorithms are designed to select the prompt muons to be used at the offline analysis level. Special reconstruction and identification algorithms are also formulated to select displaced muons, which are used in many Beyond Standard Model (BSM) searches. In this communication, the performance of the muon object obtained by CMS during the 2022 data-taking period will be discussed with a focus on improvement in the muon reconstruction at HLT using machine learning algorithm, offline efficiencies and scale factors for different identification algorithms and p_T assignment of high-p_T muons.

Study of trigger algorithm performance with phase 2 upgrade for the muon spectrometer of ATLAS experiment.

Falsetti G.
Università della Calabria e INFN Frascati, Gruppo Collegato di Cosenza

The Phase 2 upgrade of the Large Hadron Collider (LHC) at CERN will significantly increase the luminosity of proton-proton collisions, providing a new frontier in particle physics research. The Muon Spectrometer is a crucial component of the ATLAS detector, and its trigger system must be upgraded to meet the challenges of the increased luminosity. In this communication, we present the expected trigger performance of the Muon Spectrometer after Phase 2. We discuss the design and operation of the upgraded trigger system, including new hardware components and algorithms implemented in FPGA firmware that enable faster and more efficient muon identification and selection. We present the expected performance of the upgraded muon trigger system, including the trigger efficiency as a function

of muon transverse momentum measured using simulated events. Challenges faced by the system include the high background rate and the need to maintain a high trigger efficiency in the presence of pile-up. In conclusion, the upgraded system is expected to achieve higher performance and enable new discoveries, pushing the boundaries of our understanding of the fundamental nature of matter and universe.

Recent test beam results of BTL sensor prototypes.
Lombardi F.
Università di Roma I e INFN, Sezione di Roma I
The last phase of the BTL timing performance validation is based on beam test of final non-irradiated and irradiated LYSO+SiPM sensor module prototypes readout with the BTL signal processing ASIC (TOFHIR2). Recent results obtained during these tests will be will be presented and discussed.

Ultimi sviluppi dei sensori UFSD per l'Endcap Timing Layer di CMS.
Lanteri L.
Università di Torino e INFN, Sezione di Torino
La mia comunicazione riguarderà gli Ultra-Fast Silicon Detectors (UFSD), una tipologia di sensori al silicio basta sulla tecnologia Low-Gain Avalanche Diode (LGAD). Questa tecnologia consiste nell'impiantare un sottile strato altamente drogato in un tradizionale sensore al silicio; ciò permette di generare all'interno del sensore una regione ad alto campo elettrico, in grado di moltiplicare le cariche primarie rilasciate per ionizzazione al passaggio di particelle. Il risultato che si ottiene è un segnale più ampio rispetto ai classici rivelatori al silicio e un miglior rapporto segnale/rumore. Grazie al loro disegno i rivelatori UFSD, con uno spessore di circa 50 μm, permettono di effettuare misure di tempo con una risoluzione temporale di alcune decine di picosecondi. Presenterò le caratteristiche dei sensori UFSD e le principali misure effettuate sulle ultime produzioni. In particolare, mostrerò l'evoluzione della risoluzione temporale al variare della radiazione ricevuta e mostrerò i test effettuati su sensori di grandi dimensioni, ~ 4.5 cm^2, in vista del loro utilizzo per la costruzione della parte Endcap del MIP Timing Detector (MTD) per la Fase 2 del rivelatore CMS.

Aula P1 **ore 15:10 – 19:30**

Sezione I

Fisica nucleare e subnucleare

Presiede: Cobal M. (Università di Udine e INFN, Gruppo Collegato di Udine)

Relazioni su invito

▲ **Precision measurements with *b* quarks and anomalies.**

Quagliani R.

EPFL, Lausanne

Precision measurements in weak decays of heavy flavoured b-hadrons are highly sensitive to beyond-the-Standard-Model physics. In particular, flavour-changing neutralcurrent (FCNC) processes, mediated by $b \to s\ell\ell$ transitions, forbidden at the lowest perturbative order in the Standard Model (SM), might receive comparatively large corrections from new particles in SM extensions. Such corrections may affect different observables related to FCNC decays, such as branching fractions or angular distributions. $b \to s\ell\ell$ transitions can also be used as a sensitive test of Lepton Flavour Universality (LFU), a symmetry of the Standard Model implying that the coupling of the electroweak gauge bosons to leptons is flavour universal. Extensions of the SM do not necessarily preserve this symmetry and may give sizable contributions to the decay amplitudes. Several anomalies have been observed in FCNC processes, some of which have disappeared while others are still present and might hint to new physics. Recent results from the LHCb experiment on LFU tests in rare $b \to s\ell\ell$ decays are discussed, along with the status of b-flavour anomalies.

▲ ***g*-2 del muone: Scenari teorici BSM.**

Paradisi P.

Università di Padova e INFN

Il g-2 del muone rappresenta una delle più importanti osservabili della fisica delle particelle elementari per effettuare test di pecisione del modello standard e svelare o limitare possibili effetti di nuova fisica. In questa comunicazione, fornirò una rassegna dei più promettenti scenari di nuova fisica che contribuiscono al g-2 del muone e che potranno essere testati ai presenti o futuri acceleratori di particelle.

Comunicazioni

● **Ricerca della produzione di vector-like leptons in stati finali leptonici con almeno tre *b* jet con l'esperimento CMS.**

Malvaso J.

Università di Firenze e INFN, Sezione di Firenze

Il contributo riporta la ricerca della produzione di coppie di vector-like leptons nel contesto del modello "4321", proposto per spiegare le potenziali anomalie nelle misure di fisica del B. L'analisi utilizza i dati raccolti durante il Run 2 dall'esperimento CMS in collisioni protone-protone a 13 TeV, studiando stati finali in cui sono presenti leptoni carichi e almeno tre b jet. Nel contributo verranno discussi sia i risultati ottenuti in stati finali in cui si selezionano i decadimenti adronici dei leptoni tau, sia uno studio preliminare di stati finali in cui vengono selezionati almeno tre elettroni o muoni.

Higgs Physics at Muon Collider with detailed detector simulation.

Zuliani D. ([1])([3]), Lucchesi D. ([1])([3]), Casarsa M. ([2]), Sestini L. ([3]), Giambastiani L. ([1])([3]), Buonincontri L. ([1])([3])
([1]) *Università di Padova*
([2]) *INFN, Sezione di Trieste*
([3]) *INFN, Sezione di Padova*

Muon collisions at multi-TeV center-of-mass energies are ideal for studying Higgs boson properties. At these energies the production rates will allow precise measurements of its couplings to fermions and bosons. In addition, the double Higgs boson production rate could be sufficiently high to directly measure the parameters of trilinear self-couplings, giving access to the determination of the Higgs potential. This communication aims to give an overview of the results that have been obtained so far on Higgs couplings by studying the $\mu^+\mu^- \to H(b\bar{b})\nu\bar{\nu}$, $\mu^+\mu^- \to H(WW^*)\nu\bar{\nu}$ and $\mu^+\mu^- \to H(b\bar{b})H(b\bar{b})\nu\bar{\nu}$ processes. All the studies have been performed with a detailed simulation of the signal and physics background samples and by evaluating the effects of the beam-induced background on the detector performance. Evaluations on Higgs boson couplings sensitivities and results on the uncertainty on double Higgs production cross-section, together with the trilinear self-coupling, will be discussed at a center-of-mass energy of 3 TeV.

Measurement of the anomalous precession frequency in the Muon $g-2$ experiment at Fermilab.

Tassone G. ([1]), Venanzoni G. ([2])([3])
([1]) *Università della Calabria e INFN, Gruppo Collegato di Cosenza, Italia*
([2]) *INFN, Sezione di Pisa, Italia*
([3]) *University of Liverpool, UK*

The anomalous magnetic moment of the muon, denoted as $a_\mu = (g-2)/2$ is one of the most precisely measured quantities in particle physics, both experimentally and theoretically, so any deviation between the experimental and theoretical values could indicate Beyond Standard Model physics. The E821 experiment at Brookhaven National Laboratory achieved a remarkable result in 2001 by measuring the muon anomalous magnetic moment with precision of 0.54 ppm, which differed from the prediction of the Standard Model by 3.4σ. The new Muon $g-2$ experiment at Fermilab is operating with the aim to improve the precision by a factor of four compared to the previous experiment. The measurement by Run-1 confirmed the previous one by the BNL, bringing the discrepancy with the theoretical value to 4.2σ. In the meantime, new evaluations from lattice have produced results closer to the experimental value. From the experimental side analysis of Run2-3 data is in progress while analysis of Run4-5 has started. In this communication we discuss the systematic errors affecting the precession frequency analysis with a focus on the ones originated by the calorimeter measurement of positrons energy.

Studio di un algoritmo di fit cinematico sul canale $HH \to b\bar{b}\gamma\gamma$.

Orlandini R.
Dipartimento di Matematica e Fisica, Università degli Studi Roma Tre, Italia e INFN, Sezione di Roma Tre, Italia

L'accoppiamento trilineare del bosone di Higgs desta particolare interesse in quanto permette di studiare in maniera diretta il potenziale di Higgs e testare la validità del modello standard. In questa esposizione verrà presentata una particolare tecnica per migliorare l'analisi di tale misura, attualmente in corso nell'esperimento ATLAS attraverso il canale di decadimento doppio Higgs con due b-jet e due fotoni nello stato finale. Più in dettaglio, il lavoro è incentrato sull'ottimizzazione di un fit cinematico, un algoritmo di analisi dati per la fisica delle

alte energie, che ha come scopo quello di migliorare la risoluzione sui jet ricostruiti tramite l'imposizione di opportuni vincoli cinematici. In questo caso viene imposta la conservazione dell'impulso trasverso nella reazione $pp \to b\bar{b}\gamma\gamma$ (+ jet). Sarà mostrato l'impatto di questa tecnica sulla risoluzione della massa invariante dei due b-jet e il conseguente miglioramento di sensitività dell'analisi.

Development of a pattern-matching algorithm for the ATLAS Level-zero muon trigger.

Corazzina L. ([1])([2]), Bauce M. ([2]), Corradi M. ([2]), Ippolito V. ([2]), Luci C. ([1])([2]), Morodei F. ([1])([2]), Padovano G. ([1])([2]), Pompa Pacchi E. ([1])([2]), Safai Teherani F. ([2]), Vari R. ([2])

([1]) *Dipartimento di Fisica, Università di Roma La Sapienza, Italia*

([2]) *INFN, Sezione di Roma 1, Italia*

The ATLAS Level-0 muon trigger for the High-Luminosity LHC upgrade will use powerful Field-Programmable Gate Arrays (FPGAs) to perform fast trigger algorithms. In particular, the Barrel Sector Logic board will receive hit data from the RPC detectors and the Tile Calorimeter and should provide muon candidates within a latency of few hundreds of nanoseconds. Different approaches can be used to implement the trigger algorithms in the FPGA firmware: geometrical methods, neural networks, pattern matching. We discuss the development and optimization of pattern matching algorithms and we compare them to other approaches.

Electroweak measurements at LHCb with the calorimeter upgrade.

Arnone L. ([1]), Lucchesi D. ([1])([2]), Sestini L. ([2]), Zuliani D. ([1])([2])

([1]) *Università di Padova, Italia*

([2]) *Istituto Nazionale di Fisica Nucleare, Sezione di Padova, Italia*

The LHCb experiment covers the forward region of proton-proton collisions, and it can improve the current electroweak landscape by studying W and Z bosons in this phase space complementary to ATLAS and CMS. Thanks to the excellent detector performance, fundamental parameters of the Standard Model can be precisely measured by studying the properties of the electroweak bosons. In this communication an overview of the wide LHCb electroweak measurement program will be presented. The proposal of a new calorimeter for LHCb will be also presented: this calorimeter could enhance the performance on electroweak boson measurements in the High Luminosity LHC era, by precisely measuring the energy of electrons and hadronic jets in a high pile-up environment.

Assembling, noise and performance tests results of INFN of Bari PS modules for the phase-2 CMS Outer Tracker.

Margjeka I. ([1]), My S. ([1])([2]), Creanza D. ([1])([3]), Fiore L. ([1])

([1]) *INFN, Sezione di Bari*

([2]) *Università degli Studi di Bari "Aldo Moro"*

([3]) *Politecnico di Bari*

The CMS Outer Tracker phase-2 upgrade of the silicon modules is conditioned by the planned high luminosity of the HL-LHC project ($\geq$3000 fb^{-1}). It aims to deliver almost $\times$10 higher granularity, lower mass (by a factor of two) and to provide higher data rates and local track segments at 40 MHz. Such conditions are fulfilled by the pixel-strip (PS) modules, which contain a strip-sensor and a macro-pixel sensor of (5×10) cm^2 wire-bonded to two FEHs inter-connected with a power hybrid (POH) on one side and with an optical readout-hybrid (ROH) on the opposite side. The rejection of low-momentum tracks for the L1 track trigger is also performed in the FE electronics by locally correlating the signals (hits) from a pair

of pixel-strip sensor (stubs). The assembly of the PS modules and the performance tests for noise investigation are presented.

● **Simulation and optimization of the μRWELL-based Preshower and Muon detectors of the IDEA detector concept for FCC-ee.**

Ali M. ([1]), Braibant S. ([1]), Garzia I. ([2]), Giacomelli P. ([1])
([1]) *INFN, Sezione di Bologna, Bologna, Italy*
([2]) *INFN, Sezione di Ferrara, Ferrara, Italy*

The International Detector for the Electron-Positron Collider (IDEA) is a detector concept proposed for the Future Circular Collider electron-positron collider (FCC-ee). The μRWELL-based Preshower and Muon detectors are essential components of the IDEA concept. In this communication, we present the development of the full simulation using Geant4 and the DD4HEP software packages. Both detectors are geometrically made of a central cylindrical barrel, closed at the extremities by two endcaps. The two detectors are developed as being very modular, realized with a large mosaic of μRWELL detectors, each with a typical size of 50×50 cm^2. We define and examine the geometrical shape and all the materials and characteristics of the detectors. The detailed simulation comprises both the simulation of the ionizing particle interaction with the detector, as well as the simulation of the digitization of the electronics signals produced. Our results provide important insights into the optimal design and performance of these detectors. The full simulation is instrumental to tune the fast simulation that will be used to produce very large samples of events for some benchmark physics processes.

● **Quantum statistical parton distributions for the nucleons and the charged mesons.**

Buccella F., Bellantuono L., Bellotti R.
Istituto Nazionale di Fisica Nucleare

The statement of Feynman *et al.* that in the nucleon sea there is an isospin asymmetry as a consequence of the Pauli principle has been confirmed by the defect in the Gottfried sum rule and the study of the production of Drell-Yan pairs in pp and pd scattering. This leads to a role of quantum statistical mechanics. In fact the assumption that at the initial scale the valence parton distributions are described by Fermi-Dirac functions of x and the gluons by a Planck formula has received several experimental confirmations, as the correlation between the first moments of the valence parton distributions and their shapes and the spin asymmetries of the sea. More recently the gluon distribution found by the ATLAS Collaboration has been described by a Planck formula with values of the parameters very similar to the ones found 21 years ago and the parton distributions of the charged pions and kaons have been described in the framework of the statistical approach by studying the production of Drell-Yan pairs and J/ψ particle on nuclear targets. The parametrization reduces the uncertainty on the parton distributions at high x in that region, where the experimental information is scarce.

● **Measurement of the anomalous spin precession frequency ω_a in the Muon $g-2$ experiment at Fermilab.**

Cotrozzi L. per la Muon g-2 Collaboration
Dipartimento di Fisica, Università di Pisa, Italia e INFN, Sezione di Pisa

The muon anomaly $a_\mu = (g_\mu - 2)/2$ is a low-energy observable which can be both measured and computed to high precision, making it a sensitive test of the Standard Model (SM). The current discrepancy between the experimental value and the SM calculation from the Muon $g-2$ Theory Initiative amounts to $(251 \pm 59) \cdot 10^{-11}$ with a significance of $4.2\,\sigma$. In April

2021 the FNAL E989 Collaboration published the first result based on the first year of data taking, and this year a new result is expected to be published, based on the Run-2/3 datasets. A 3.1 GeV muon beam is injected into a storage ring of 14 m of diameter, in the presence of a 1.45 T magnetic field. The anomaly a_μ can be extracted by accurately measuring the anomalous muon spin precession frequency ω_a and the magnetic field environment using Nuclear Magnetic Resonance techniques. The measurement of ω_a is based on the arrival time distribution of decay positrons observed by 24 electromagnetic calorimeters. This talk will show the latest results of the ω_a analysis and the progress on systematics since the first result.

ATLAS ITk Pixel for HL-LHC.

Palazzo A.
Università del Salento and INFN Lecce

At the High-Luminosity Large Hadron Collider, the instantaneous luminosity is expected to reach unprecedented values, resulting in up to 200 proton-proton interactions per bunch crossing. To cope with the resulting increase in occupancy, bandwidth and radiation damage, the ATLAS Inner Detector will be replaced by an all-silicon system, the Inner Tracker (ITk), where the innermost part will consist of a pixel detector with about 14 m^2 of active area. The latest development and results of ATLAS ITk Pixel integrated prototypes are presented.

Measurement of the deuteron coalescence probability in and out of the jets with ALICE.

Rasà M. per la ALICE Collaboration
Dipartimento di Fisica e Astronomia "E. Majorana", Università degli Studi di Catania, Italia e Istituto Nazionale di Fisica Nucleare, Sezione di Catania, Catania, Italia

ALICE is the most suited experiment at the LHC to study light (anti)nuclei production in high-energy hadronic collisions. These studies are important to investigate the production mechanism of light (anti)nuclei, which is still not well understood and remains a highly debated topic in the scientific community. One of the phenomenological models typically used to describe the experimental data is the coalescence model, where light (anti)nuclei are formed if the phase-space configuration of nucleons at kinetic freezeout is compatible with the Wigner density of the bound state. A striking prediction of the coalescence model is an enhanced coalescence probability of nuclei in jets with respect to the underlying event in small collision systems. In this communication, the p_{T}-differential production yields and the coalescence parameter of (anti)deuterons in and out of the jet, measured in pp and p-Pb collisions, will be presented. The results are compared with expectations from coalescence and a reaction-based model. Finally, the perspectives for further developments of this research line in the LHC Run 3 will be discussed.

Aula F8 - Maria Marinaro **ore 15:10 – 19:30**

Sezione II
Fisica della materia
Presiede: Marino A. (ISASI-CNR)

Relazioni su invito

▲ **Superflow in ultracold atomic rings: From persistent currents to Kelvin-Helmholtz instability.**
Del Pace G. ([1]), Hernandez Rajkov D. ([2]), Grani N. ([1])([2]), Muzi Falconi A. ([2])([3]), Fedrizzi M. ([2]), Xhani K. ([2]), Kwon W.J. ([2])([4]), Scazza F. ([2])([3]), Inguscio M. ([2])([5]), Modugno M. ([6]), Fort C. ([1])([2]), Marino F. ([2])([7]), Roati G. ([2])
([1]) *University of Florence, Sesto Fiorentino, Italy*
([2]) *LENS and INO-CNR, Sesto Fiorentino, Italy*
([3]) *University of Trieste, Trieste, Italy*
([4]) *UNIST, Ulsan, Republic of Korea*
([5]) *Campus Biomedico University of Rome, Rome, Italy*
([6]) *University of the Basque Country, IKERBASQUE and EHU Quantum Center, Bilbao, Spain*
([7]) *INFN Sez. di Firenze, Italy*
The emergence of persistent currents (PC) in rings is one of the most striking manifestations of quantum coherence. The periodic boundary of such a geometry constrains the wavefunction phase to wind in a loop of an integer multiple of 2π, which gives rise to a notably stable current, protected by its topological nature. Here, I report on our recent experimental studies on the stability of PC in fermionic superfluid rings of ultracold atoms. In a first work, we demonstrate a fast and accurate technique to excite PCs of circulation as high as 9 and probe their stability in the presence of a controlled impurity. All currents are observed to be unperturbed by the defect up to a critical value, above which vortices enter the superfluid bulk, tearing away circulation quanta and inducing the current decay. In a second work, we scale up our system to a concentric double ring geometry and investigate the stability of the interface between counterflowing currents by merging the two rings. The circular vortex array constituting the interface is observed to be unstable, undergoing a rolling-up dynamics with growing rates consistent with the one expected for Kelvin-Helmholtz instability.

▲ **Liquid-vapour coexistence line and critical point in attractive Bose mixtures: A path-integral quantum Monte Carlo study.**
Giorgini S. ([1]), Spada G. ([1]), Pilati S. ([2])
([1]) *Pitaevskii Center on Bose-Einstein Condensation, CNR-INO and Dipartimento di Fisica Università di Trento, Trento*
([2]) *School of Science and Technology, Physics Division, Università di Camerino, Camerino and INFN, Sezione di Perugia, Perugia*
We present a study of the thermodynamic behavior of attractive binary Bose mixtures using exact path-integral Monte Carlo methods. Our focus is on the regime of interspecies interactions where the ground state is in a self-bound liquid phase, stabilized by beyond mean-field effects. We calculate the isothermal curves in the pressure vs density plane for different values of the attraction strength and establish the extent of the coexistence region between liquid and vapor using the Maxwell construction. Notably, within the coexistence

region, Bose-Einstein condensation occurs in a discontinuous way as the density jumps from the normal gas to the superfluid liquid phase. Furthermore, we determine the critical point where the line of first-order transition ends and investigate the behavior of the density discontinuity in its vicinity. We also point out that the density discontinuity at the transition could be observed in experiments of mixtures in traps.

▲ **Micromasers as quantum batteries.**

Benenti G. ([1])([2]), Shaghaghi V. ([1])([2])([3]), Singh V. ([3]), Carrega M. ([4]), Rosa D. ([3])
([1]) *Center for Nonlinear and Complex Systems, Dipartimento di Scienza e Alta Tecnologia, Università degli Studi dell'Insubria, Como, Italy*
([2]) *Istituto Nazionale di Fisica Nucleare, Sezione di Milano, Milano, Italy*
([3]) *Center for Theoretical Physics of Complex Systems, Institute for Basic Science ,IBS, Daejeon, Korea*
([4]) *CNR-SPIN, Genova, Italy*

Quantum technologies, i.e. technological devices obtained by building and manipulating quantum mechanical systems, are becoming a reality in recent days. Since they need energy to operate, the concept of quantum batteries, which are quantum mechanical systems used as energy storage devices, has been developed. It is therefore of uttermost importance to find suitable quantum platforms which could be used as quantum batteries. It is shown that a micromaser, where a beam of qubits is used to charge the electromagnetic field in a cavity, is an excellent model of quantum battery. Indeed, a highly excited, pure, and effectively steady state of the cavity mode, charged by coherent qubits, can be achieved, also in the ultra-strong coupling regime of field-matter interaction. Stability of these appealing features against loss of coherence of the qubits and the effect of counter-rotating terms in the interaction Hamiltonian are also discussed.

Comunicazioni

● **Superfluids and supersolids in a ring.**

Preti N. ([1]), Antolini N. ([2])([3]), Biagioni G. ([1])([2]), Dardier T. ([4]), Fioretti A. ([2]), Gabbanini C. ([2]), Tanzi L. ([2]), Modugno G. ([1])([2])([3])
([1]) *Dipartimento di Fisica e Astronomia, Università degli studi di Firenze, Italia*
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([4]) *Ecole Normale Supérieure, Paris, France*

In the mid '90s the experimental realization of BEC in ultracold atoms paved the way to a series of ground-breaking discoveries. Among them, an important recent achievement has been the observation of a new phase of matter, the supersolid, about 50 years after its first theoretical proposals. Previous results in the supersolid community proved that this newly discovered phase of matter indeed possesses the properties of both a superfluid, showing coherence and a reduced moment of inertia when rotated, and those of a solid, featuring a spontaneous density modulation. We will report on an ongoing experiment regarding the superfluid nature of the supersolid, done in collaboration with the BEC center in Trento. Our aim is to trap the supersolid in an optical potential shaped as a ring, made through the use of a digital micromirror device. By doing so we will be able to study its rotation properties in the same configuration used in the past for standard superfluids and superconductors. Moving from the supersolid to a standard superfluid through a reversible quantum phase transition, we will be able to test for the first time the seminal theory by the Nobel laureate A. Leggett.

A variational method for the study of particle aggregates.

Triggiani F. ([1])([2]), Simonucci S. ([1])([2]), Taioli S. ([3])([4])([5]), Morresi T. ([3])([4])
([1]) *University of Camerino - Department of Physics, Italy*
([2]) *INFN, Section of Perugia, Italy*
([3]) *ECT*-FBK, Italy*
([4]) *INFN-TIFPA - Trento, Italy*
([5]) *Gdańsk University of Technology, Poland*

In this work we present a variational method for the study and analysis of multi-particle systems. This approach has been employed by us to calculate the energies of the ground state and first excited states of ions, atoms and molecules, such as the positronium negative ion (Ps^-), the hydrogen molecule (H_2) and the helium atom (He). The wave functions have been expanded using optimized multi-dimensional Gaussian functions basis sets. An advantage of using Gaussian basis functions consists in deriving analytical expressions of the integrals essential for the calculation of the matrix elements. The results obtained, compared with both theoretical and experimental values, are in good agreement with the most recent data in the literature.

Dissipative vortex dynamics in homogeneous fermionic superfluids.

Grani N. ([1])([2])([3]), Hernández-Rajkov D. ([1])([2]), Daix C. ([1])([3]), Inguscio M. ([1])([2])([4]), Xhani K. ([2]), Scazza F. ([1])([2])([5]), Del Pace G. ([3]), Kwon W. ([6]), Roati G. ([1])([2])
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In superfluid and superconducting systems, the absence of viscosity and resistance gives the possibility to sustain persistent currents. However, the emergence of quantized vortices can affect this property. In particular, their motion can lead to dissipation even in these types of systems via phase-slippage processes. In our system we excite persistent currents in an annular fermionic superfluid and we observe the role of vortices in the current decay process in the presence of impurity. Moreover we study the dissipation process underlying the vortex dynamics by exciting on demand vortices configurations in a homogeneous disk with a high control over their position. In particular we probe dissipation effects by tracking the vortex trajectories in two simple cases: a vortex dipole and a single vortex moving in a background superflow.

Dipolar physics in low dimensions: From the gas, to the liquid and droplet formation.

Citro R. ([1]), De Palo S. ([2])([3]), Orignac E. ([4]), Salasnich L. ([5])
([1]) *Dipartimento di Fisica "E.R. Caianiello", Università degli Studi di Salerno and CNR-SPIN, Fisciano, SA, Italy*
([2]) *CNR-IOM-Democritos National UDS, Trieste, Italy*
([3]) *Dipartimento di Fisica Teorica, Università Trieste, Trieste, Italy*
([4]) *Univ Lyon, Ens de Lyon, CNRS, Laboratoire de Physique, Lyon, France*
([5]) *Dipartimento di Fisica e Astronomia "Galileo Galilei" and QTech, Università di Padova, Padova, Italy*

We theoretically investigate the ground-states properties, the radial collective oscillations and the droplets formation in a quasi-one-dimensional dipolar gas of bosonic atoms. We model the dipolar gas with an effective quasi-one-dimensional Hamiltonian and derive the equation of state using a variational approximation based on the Lieb-Liniger gas Bethe ansatz wave function or perturbation theory. We calculate the density profile and show that when the strength of the dipolar interaction becomes sufficiently attractive compared to the contact one, a solitonic-like density profile evolves into a liquid-like droplet. The incipient gas-liquid transition is also signaled by a steep increase of the breathing mode and a change in sign of the chemical potential. Upon a sudden release of the trap the numerical solution of a time-dependent generalized Gross-Pitaevskii equation shows that the droplet either evaporates or forms a single self-bound droplet or fragments in multiple droplets, depending on the number of trapped atoms and the scattering length. These results can help in characterizing the effect of the dipolar interaction in a quasi-one-dimensional geometry *vs.* the 3D geometry.

Spin-orbit density dependence and compacton existence in Bose-Einstein condensates.

Salerno M., Abdullaev F.Kh., Hadi M.S.A., Umarov B., Taib L.A.

Dipartimento di Fisica "E.R.Caianiello", Università di Salerno, Fisciano, SA, Italy

We investigate binary mixtures of Bose-Einstein condensates (BEC) trapped in deep optical lattices (OL) subjected to equal contributions of intra-species Rashba and Dresselhaus spin-orbit coupling (SOC) under periodic time modulations of the intra-species scattering length. We show that these modulations lead to a rescaling of the SOC parameters that involves the density imbalance of the two components and strongly influence the existence of compacton matter waves. The stability of SOC-compactons is investigated both by linear stability analysis and by time integrations of the coupled Gross-Pitaevskii equations. We find that while SOC restricts the parameter ranges for stable SOC-compactons existence, it gives more stringent signatures of their occurrence. In particular, SOC-compactons should appear when the intra-species interactions and the number of atoms in the two components are perfectly balanced or close to being balanced for the metastable case. The possibility to use SOC-compactons as a tool for indirect measurements of the number of atoms and/or the intra-species interactions is also suggested.

Determining the number of clusters, before finding clusters, from the susceptibility of the similarity matrix.

Lippiello E., Baccari S., Bountzis P.

University of Campania "L. Vanvitelli"

Clustering represents a fundamental procedure to provide users with meaningful insights from an original data set. The quality of the resulting clusters is largely dependent on the correct estimation of their number, K^*, which must be provided as an input parameter in many clustering algorithms. Only very few techniques provide an automatic detection of K^* and are usually based on cluster validity indexes which are expensive with regard to computation time. Here, we present a new algorithm which allows one to obtain an accurate estimate of K^*, without partitioning data into the different clusters. This makes the algorithm particularly efficient in handling large-scale data sets from both the perspective of time and space complexity. The algorithm, indeed, highlights the block structure which is implicitly present in the similarity matrix, and associates K^* to the number of blocks in the matrix.

Slave-spin mean field for broken-symmetry states: Néel antiferromagnetism and its phase separation in multi-orbital Hubbard models.

Crispino M., Chatzieleftheriou M., Gorni T., de' Medici L.
ESPCI Paris - PSL

We introduce the generalization of the slave-spin mean-field method to broken-symmetry phases. Through a variational approach we derive the single-particle energy shift in the mean-field equations which generates the appropriate self-consistent field responsible for the stabilization of the broken symmetry. With this correction the different flavours of the slave-spin mean field are actually the same method and they give identical results to Kotliar-Ruckenstein slave-bosons and to the Gutzwiller approximation. We apply our formalism to the Néel antiferromagnetic state and study it in multi-orbital models as a function of the number of orbitals and Hund's coupling strength, providing phase diagrams in the interaction-doping plane. We show that the doped antiferromagnet in proximity of half filling is typically unstable towards insulator-metal and magnetic-nonmagnetic phase separation. Hund's coupling extends the range of this antiferromagnet, and favors its phase separation.

Tight binding simulation of laser-assisted ultrafast field-emission from correlated metal.

D'Onofrio L.J. ([1])([2]), Avella A. ([1])([3])([4]), Eckstein M. ([2])([5])
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([5]) *Department of Mathematics and the Cluster of Excellence "CUI: Advanced Imaging of Matter", University of Hamburg, Hamburg, Germany*

Field-emission is a powerful technique to gain insight into the electronic properties of materials. A strong and ultrashort laser pulse can periodically modify the potential barrier for electron tunnelling, giving rise to photon sidebands in the far-field electron energy distribution. The aim of this work is to investigate how interaction effects, as well as decoherence, become manifest in this energy spectrum. We simulate the laser-assisted field-emission experiment by means of two linked Hubbard chains, one for the solid and another one for vacuum where electrons can propagate. The out-of-equilibrium electron dynamics of this inhomogeneous system is described using the Keldysh Green's function formalism, while the correlation inside the solid is treated in a DMFT framework.

Electrically driven spin-orbital correlations in spin-orbit coupled Mott systems.

Forte F. ([1])([2]), Cuoco M. ([1])([2]), Noce C. ([2])
([1]) *CNR-SPIN Salerno, Italia*
([2]) *Dip. di Fisica "E.R. Caianiello", Università degli Studi di Salerno, Italia*

In transition metal oxides, quantum phases marked by strong electron correlations are prone to dramatic reconstructions due to the interplay between multiple degrees of freedom and external perturbations. Particularly, for the Mott insulator Ca_2RuO_4 (CRO), comparable scales related to the kinetic energy of carriers, spin-orbital magnetic exchange, and structural distortions, lead to a near degeneracy of quantum states, which make it highly sensitive to external stimuli. Recently, it has been shown that a moderate electric field in CRO can lead to novel phases absent at equilibrium, marked by a spatial reconstruction involving magnetic, orbital and lattice degrees of freedom. In this talk, I will present the results of a theoretical study, which focuses on the prominent role played by the orbital degree of freedom in CRO,

and its interplay with charge, spin and lattice, when out-of-equilibrium forces are exerted. I will discuss how the spin-orbital correlations are dramatically affected by the application of a static electric field, with a reduction of the antiferromagnetism, and the possibility of having a collapse of the orbital order.

Mott insulators with boundary zeros.

Sangiovanni G.
University of Wuerzburg

In the recent literature, the concept of topological Mott insulator has been spelled out in quite different ways. Most of the proposed realizations rely either on Hartree-Fock approximations or on appropriately defined auxiliary degrees of freedom. I will discuss a novel, remarkably simple way of describing a topological Mott insulator without long-range order based on the topological properties of their Green's function zeros in momentum space. After discussing the fate of the bulk-boundary correspondence in these systems, I will show how the zeros can be seen as a form of "topological antimatter" with distinctive features associated to the annihilation with conventional topologically protected edge modes.

Density functional theory investigation of the interplay between magnetism and topology in dilute magnetic semiconductors.

Cuono G.
International Research Centre Magtop, Institute of Physics, Polish Academy of Sciences, Warsaw, Poland

Here we investigate the electronic and magnetic properties of the dilute magnetic semiconductors $Cd_{1-x}Cr_xTe$, $Hg_{1-x}Cr_xTe$, $Cd_{1-x}V_xTe$, $Hg_{1-x}V_xTe$ by using a density functional theory approach which goes beyond the standard functionals in order to correctly reproduce the topology and the band gap of these systems. We obtain the band structures of these systems, we study the distortions produced by the Jahn-Teller effect and the crystal field splitting of the *d*-levels of the dopants. We find that the crystal field strongly depends on the correlations. Then, we study the exchange couplings for all considered cases and we find that the coupling is ferromagnetic in case of doping with V, differently from the case of doping with Mn and Cr, where we find antiferromagnetic couplings. The ferromagnetic coupling among V atoms in the insulating phase of topological HgTe can produce the quantum anomalous Hall phase. We also checked the interplay between the distortions produced by Jahn-Teller effect and magnetism and we found that the distortions favor the ferromagnetism.

GaN on Si Power and RF Devices and Application.

Castagna M.E. ([1]), Chini A. ([2]), Tringali C. ([1]), Moschetti M. ([1]), Cristina Miccoli C. ([1]), Gervasi L. ([1]), Giorgino G. ([1])([2]), Luongo G. ([1]), Cioni M. ([1]), Iucolano F. ([1])
([1]) *STMicroelectronics, Catania, Italy*
([2]) *Department of Engineering "Enzo Ferrari" DIEF, University of Modena and Reggio Emilia, Italy*

GaN-based High Electron Mobility Transistors (HEMTs) are well suited to high power/frequency applications thanks to the many intrinsic benefits of the material. During the operation in actual applications, e.g., in power converters, GaN devices are switching for many cycles, thus inducing power dissipation (conduction and switching losses). Therefore, heat production generates an increase of the device temperature, drifting its characteristics from the ones expected at room temperature. Therefore, p-GaN gate transistors have been deeply analyzed both in DC and dynamic conditions at high operating temperature (up to 150°C). The relevance of the resistive component under the p-GaN gate in the 100V technology under exam has been proved, showing that its increase with temperature is caused by the

positive VTH shift and by the gm degradation, so is important to achieve a stable Vth in temperature. RF applications usually do not require normally-off operation, enabling the exploitation of the total 2DEG density. Moreover, requirements for RF devices typically involve high maximum saturation current and high output power at high frequency operation. The trade-off between DC/RF performances and reliability specifications has been analysed by comparing devices with increasing Aluminum concentration in the AlGaN barrier: an optimal Al% must be chosen for ensuring adequate device robustness while targeting sufficiently high current and power levels.

Dislocation density evolution in PVT growth of 150 and 200 mm SiC.

Ellison A. ([1]), Sundqvist B. ([1]), Sörman E. ([1]), Lilja L. ([1]), Lima L.M.C. ([1])([2]), Paradiso D. ([1])([2]), Westberg N. ([1]), Hult P. ([1]), Riva L. ([2]), Carria E. ([2]), Gritti A. ([1]), Bergman P. ([1]), Magnusson B. ([1])

([1]) *STMicroelectronics Silicon Carbide AB, Norrköping, Sweden*

([2]) *STMicroelectronics, Analog and Power Front-End Manufacturing, Catania, Italy*

In order to support a rapid adoption of energy efficient SiC power devices in e.g. automotive applications, it is valuable to minimize, in a cost-effective way, the density of dislocations that can reduce the device yield and reliability. A certain percentage of Threading Screw Dislocations (TSD) could reduce the reliability of MOSFETs when they produce a surface nano-pit in the active epilayer. Basal Plane Dislocations (BPD) are well known to induce degradation of bipolar devices, such as a body diode. In this study, we describe the evolution of the density of Threading Edge Dislocations (TED), BPDs and TSDs (pure and mixed) along the growth direction in SiC bulk crystals. 150mm 4H-SiC n-type wafers (4° off-axis) were manufactured from ingots grown by a PVT method developed at STM Sweden. The dislocation density was measured on the Si-face by KOH etching two wafers per ingot, one close to the start, and one close to the end of the growth. For TSD mapping, low n-doped epilayers were grown prior to etching, so that TSDs (pure or mixed) could reliably be identified by their larger etch pit area than TEDs, based on an earlier correlation with X-ray topography. For BPD mapping, the recognition of the shell-shape of the etch pits was used after etching the Si-face of bare n+ substrates. In an optimized PVT process, the selection of the seed is of key importance towards lowering TSD and BPD-TED densities, and this has allowed the crystal growth expansion to 200mm wafers.

Demonstration of long-range quantum state teleportation.

Leandro L., Ella L., Drucker N., Villegas K.A., Kurman Y., Sivan I., Cohen Y., In Collaboration with Google Quantum AI

Quantum Machines Inc., TelAviv, Israel

Adaptive quantum circuits, in which gates are conditioned on mid-circuit measurement results, are emerging as enables for expanding the capabilities of NISQ processors beyond what is possible today. In particular, they allow for efficient preparation of topologically-ordered and non-abelian states of matter and for observing measurement induced phase transitions. The canonical example of an adaptive circuit is state teleportation, which serves both as a fundamental building block in measurement-based quantum computation schemes as well as allows for quantum state routing in constant-depth between distant qubits. In this work, we demonstrate, for the first time, teleportation-based routing across a chain of 7 superconducting qubits. This requires both ultra-low latency real time feedback with logical classical operations within the coherence time, as well as the generation of a highly entangled state between all qubits. This work paves the way for the efficient simulation of exotic states of matter on NISQ processors by greatly expanding the capabilities of present-day superconducting quantum processors.

Fondazione Aula 1 - Edificio S2 **ore 15:10 – 19:30**

Sezione II

Simposio di Fisica Statistica e Sistemi Complessi

Presiedono: Nicodemi M. (Università di Napoli Federico II)
Spagnolo B. (Università di Palermo)

Relazioni su invito

▲ **Some new results in random matrix theory.**

Cugliandolo L., Venturelli D., Schehr G., Tarzia M.
SISSA, LPTHE Sorbonne Université and LPTMC Sorbonne Université

I will discuss new results on the properties of square random matrices, focusing on the Rosenzweig-Porter and sparse kind.

▲ **Extended-range percolation in complex networks.**

Castellano C. ([1])([2]), Cirigliano L. ([2])([3]), Timar G. ([4])
([1]) *Istituto dei Sistemi Complessi, ISC-CNR, Rome, Italy*
([2]) *Centro Ricerche Enrico Fermi, Rome, Italy*
([3]) *Dipartimento di Fisica Università "Sapienza", Rome, Italy*
([4]) *Departamento de Física, Universidade de Aveiro, Aveiro, Portugal*

Classical percolation theory underlies many processes of information transfer along the links of a network. In these standard situations, the requirement for two nodes to be able to communicate is the presence of at least one uninterrupted path of nodes between them. In a variety of more recent data transmission protocols, such as the communication of noisy data via error-correcting repeaters, both in classical and quantum networks, the requirement of an uninterrupted path is too strict: two nodes may be able to communicate even if all paths between them have interruptions/gaps consisting of nodes that may corrupt the message. In such a case a different approach is needed. We develop the theoretical framework for extended-range percolation in networks, describing the fundamental connectivity properties relevant to such models of information transfer. We obtain exact results, for any range d, for infinite random uncorrelated networks and we provide a message-passing formulation that works well in sparse real-world networks. The interplay of the extended range and heterogeneity leads to novel critical behavior in scale-free networks.

▲ **Stochastic gradient descent-like relaxation is equivalent to Glauber dynamics in discrete inference problems.**

Angelini M.C., Cavaliere A., Marino R., Ricci-Tersenghi F.
Dipartimento di Fisica, Sapienza Università di Roma

The temperature in a Monte Carlo algorithm governs the randomness that allows exploring a complex energy landscape. In contrast, in a Stochastic Gradient Descent (SGD) algorithm there is no temperature, and the parameter that controls the degree of randomness is given by the size of the mini-batch used. Despite SGD is widely used, a careful analysis of the optimal mini-batch size is missing. I will discuss the performances of these two well-known algorithms for discrete optimization and inference problems: despite their deep differences (SGD-like algorithm does not satisfy Detailed Balance, while Monte Carlo algorithm does), I will show that there exists an equivalence between their dynamics both at equilibrium and out of equilibrium. This is of particularly importance in understanding how to choose the optimal mini-batch size.

▲ **Absolute negative mobility of an active tracer in a crowded environment.**
Sarracino A. ([1]), Rizkallah P. ([2]), Bénichou O. ([3]), Illien P. ([2])
([1]) *Dipartimento di Ingegneria, Università della Campania Luigi Vanvitelli*
([2]) *Sorbonne Université, CNRS, Laboratoire de Physico-Chimie des Electrolytes et Nanosystèmes Interfaciaux, PHENIX*
([3]) *Sorbonne Université, CNRS, Laboratoire de Physique Théorique de la Matière Condensée, LPTMC*
Absolute negative mobility (ANM) refers to the situation where the average velocity of a driven tracer is opposite to the direction of the driving force. This effect was evidenced in different models of nonequilibrium transport in complex environments, whose description remains effective. Here, we provide a microscopic theory for this phenomenon. We show that it emerges in the model of an active tracer particle submitted to an external force, and evolving on a discrete lattice populated with mobile passive crowders. We compute analytically the velocity of the tracer particle as a function of the different parameters of the system. We determine the range of parameters where ANM can be observed and clarify the mechanism underlying ANM and its relationship with negative differential mobility.

▲ **Probing non-equilibrium dynamics in critical active systems.**
Gnan N. ([1]), Maggi C. ([2]), Paoluzzi M. ([3]), Zaccarelli E. ([1]), Crisanti A. ([4])
([1]) *Istituto dei Sistemi Complessi, CNR-ISC, Consiglio Nazionale delle Ricerche, Roma, Italia*
([2]) *Istituto di Nanotecnologie, CNR-Nanotec, Consiglio Nazionale delle Ricerche, Roma, Italia*
([3]) *Departament de Física de la Matèria Condensada, Universitat de Barcelona, Barcelona, Spain*
([4]) *Dipartimento di Fisica, Università "Sapienza", Roma, Italia*
Active systems exhibit a wide range of non-equilibrium phenomena, such as motility-induced phase separation (MIPS) which leads to self-organization of active particles on large scales. Although MIPS arises from a non-equilibrium process, recent studies suggest that its critical point belongs to the equilibrium Ising universality class. It is therefore interesting to investigate what is the role played by non-equilibrium dynamics at the critical point of the MIPS. A powerful strategy to unveil non-equilibrium fluctuations is to search for violations of the Fluctuation Dissipation Theorem (FDT). By implementing massive computer simulations and a novel field theoretical description of a microscopic model of active particles, we reveal a strong violation of FDT at high frequencies and large wave-vectors even close to criticality. However, at low spatial and temporal frequencies, the response and correlator tend to coincide, validating the effective equilibrium picture at large scales. Our study unveils a strikingly different type of non-equilibrium behavior in critical active systems compared, for example, to glassy systems, highlighting the unique nature of active matter dynamics.

Comunicazioni

● **Machine learning for tractor noise recognition: A general paradigm for noisy signals.**
Ortenzi L., Riccioni S., Cecchini M., Alemanno R.,, Bianchini L., Di Stefano V.
University of Tuscia, Viterbo, Italy
Though Machine Learning (ML) algorithms are prone to inductive bias, ML analysis of physical signals, thanks to the underlying physical laws, overcomes this risk. Thus, ML is used to enhance the signal-to-noise ratio and renders the relations between physical quantities more transparent. I will show the results obtained in recognizing cabin tractors and non-cabin

tractors from the noise measured close (10 to 40 cm) to the operator ear. An artificial neural network (ANN) model was applied to the signals of 354 agricultural tractors. Afterwards, a variable impact analysis was performed by applying the ANN to the training set and switching off one variable at the time to check its detrimental impact on the model accuracy. Given the good model performance, it was possible to trace back the most informative features: the high frequency (8 kHz) signal and the equivalent level LAeq (dBA). While the importance of the former variable was expected, surprisingly it was found that the cabin introduces a high and dangerous noise source: the side door closing. This is an important problem for worker's health and the results obtain suggest a more general approach for the analysis of noisy signals.

On a multiscale mean-field spin glass.

Mingione E., Contucci P.
Dipartimento di Matematica, Università di Bologna, Italia

We will consider a mean-field disordered system with Sherrington-Kirkpatrick Hamiltonian in the presence of multiple thermal equilibria, namely assuming that the random coupling can be divided into a finite number of families having their own effective equilibrium temperature. The generating functional (thermodynamic pressure) of the model is constructed trough a hierarchical sequence of annealed averages, reminiscent of the Replica Symmetry Breaking interpolation. The above construction can be also seen as a multiscale decomposition of the Hamiltonian viewed as a Gaussian process. We show that the thermodynamic limit of the pressure per particle can be represented as a solution of an infinite dimensional variational principle of the Parisi type. In particular we will show that the multiscale structure acts as constraint in the space of functional order parameter.

Voter model with long-range interactions.

Smaldone L. ([1])([2]), Corberi F. ([2])
([1]) *University of Warsaw, Poland*
([2]) *Università di Salerno, Italy*

We analytically study the behavior of the voter model with long-range interactions. In particular we compute the size L_α of ordered regions and the consensus time τ_α, for different regimes.

Dissipative symmetry breaking in non-equilibrium steady states.

Busiello D.M. ([1]), Sireci M. ([2])
([1]) *Max Planck Institute for the Physics of Complex Systems*
([2]) *University of Granada*

The connection between dissipation and symmetry breaking is a long-standing enigma in statistical physics. It is intimately connected to the quest of a non-equilibrium functional whose minimization gives the non-equilibrium steady state (NESS). Writing down such a functional, we show that, in the presence of additive noise, any NESS is characterized by the minimum entropy production compatible with the maximum dissipation along cycles in the trajectory space. This result sheds light on the excess entropy production principle and the onset of chiral symmetry breaking out of equilibrium, indicating that the housekeeping dissipation is connected with the tendency of performing cycles in a preferential direction. Finally, when multiplicative noise is present, we find that the non-equilibrium functional has two dissipative symmetry-breaking contributions, one stemming from cycles and the other from a thermophoresis-like effect. Our framework paves the way to understand selection phenomena as symmetry-breaking processes driven by non-equilibrium dissipation.

Diversity begets stability: Sublinear growth and competitive coexistence across ecosystems.

Mazzarisi O., Hatton I., Altieri A., Smerlak M.
Department of Ecology and Evolutionary Biology and Center for Ecological Research, University of Kansas, Lawrence, KS, USA

The unfolding global biodiversity crisis brings special urgency to understanding how diverse ecosystems are naturally maintained. Whereas conventional wisdom and empirical observation suggest that stability increases with diversity, ecological theory has long made the opposite prediction, leading to the longstanding "diversity-stability debate". Here we show this puzzle is resolved through a form of population self-regulation, whereby growth scales as a sublinear power law with biomass (exponent < 1), analogous to growth models of individual ontogeny. We show that competitive interactions in a community with sublinear growth do not lead to exclusion, but instead promote stability at higher diversity. In addition to realigning theory with observation and large-scale macroecological patterns, our model makes an unsettling prediction: biodiversity loss may accelerate the destabilization of ecosystems.

Laplacian renormalization group for heterogeneous networks: Information core and entropic transitions.

Gabrielli A. ([1]), Caldarelli G. ([2]), Gili T. ([3]), Villegas P. ([4])
([1]) *Dipartimento di Ingegneria Civile, Informatica e delle Tecnologie Aeronautiche, Università degli Studi "Roma Tre", Roma*
([2]) *Dipartimento di Scienze Molecolari e Nanosistemi, Università degli Studi Ca' Foscari, Venezia*
([3]) *Scuola IMT Alti Studi Lucca*
([4]) *Centro Ricerche "Enrico Fermi" - CREF, Roma*

Complex networks exhibit a rich architecture over multiple intertwined scales. Information pathways pervade these scales reflecting the hidden complex structural organization, while small-world effects correlate network structures and functional cores complicating their identification. We perform a new analysis of information diffusion in complex networks to shed further light on these issues. This leads us to a formulation of a new and general renormalization group (RG) scheme for heterogeneous networks. RG is the cornerstone of the modern theory of universality and phase transitions, a powerful tool to scrutinize symmetries and correlation scales in physical systems. However, its network counterpart is particularly challenging due to the intrinsic topological heterogeneity. Here, we propose a Laplacian RG diffusion-based picture for complex networks, defining both the real and the momentum space procedure and applying this RG scheme to real networks in a natural and parsimonious way.

Thermodynamic limits of sperm swimming precision.

Maggi C. ([1]), Nath B. ([2]), Saglimbeni F. ([1]), Carmona Sosa V. ([3]), Di Leonardo R. ([3]), Puglisi A. ([2])
([1]) *NANOTEC-CNR, Institute of Nanotechnology, Soft and Living Matter Laboratory, Roma, Italy*
([2]) *ISC-CNR, Institute for Complex Systems, Rome, Italy*
([3]) *Dipartimento di Fisica, Sapienza Università di Roma, Rome, Italy*

Sperm swimming is crucial to fertilise the egg in nature and in assisted reproduction. In this talk I will show how we have implemented a passive technique for the amplification of motile bull sperm concentration. This is realised by building micro-chambers capable of trapping swimming sperms yielding a significant enhancement of motile cells density in the traps. Fabricating chambers with different shape and size highlights the ingredients that are

key to optimal trap design. In the second part of the talk I will show we have used an array of micro-cages to trap the sperms' cell bodies and accurately track the spatial modes of the sperms' flagella during their beating cycle. By studying accurately the fluctuations of the dynamics of the flagellum we find that the maximum precision of this motion is close to the estimated precision of one single dynein molecular motor actuating the flagellar axoneme. I will discuss how the maximum precision of individual molecular motors is related to their energy dissipation by the thermodynamic uncertainty relation and how the precision level of the whole flagellum can be explained by a schematic model with strong motor-motor coupling.

Stochastic modeling of solar irradiance in a complex trophic web.

Valenti D.

Dipartimento di Fisica e Chimica "E. Segré", Group of Interdisciplinary Theoretical Physics, Università di Palermo

The analysis of experimental data of the solar irradiance, collected on the sea surface, highlights the intrinsic stochasticity of such an environmental variable. Given this result, the effects of randomly fluctuating irradiance on the population dynamics of a marine ecosystem are studied on the basis of the stochastic 0-dimensional biogeochemical flux model (BFM). The noisy fluctuations of the irradiance are formally described by a multiplicative Ornstein-Uhlenbeck process, i.e., a self-correlated Gaussian noise. Nonmonotonic behaviours of the variance of the marine populations' biomass are found with respect to the intensity and the autocorrelation time of the noise source, manifesting a noise-induced transition of the ecosystem to an out-of-equilibrium steady state. Moreover, noise-induced effects in the organic carbon cycling processes, underlying the food web dynamics, are observed. These findings clearly show the profound impact the stochastic behaviour of environmental variables can have on both biological and chemical components of a marine trophic network.

Stretching an extensible discrete wormlike chain (EDWLC).

Fiasconaro A. ([1])([2])([3]), Falo F. ([1])([2])

([1]) *Department of Condensed Matter Physics, University of Zaragoza, Spain*

([2]) *Institute for Biocomputation and Physics of Complex Systems, University of Zaragoza, Spain*

([3]) *Institute of Biophysics, National Research Council - Palermo Unit, Italia*

Based on classical statistical mechanics, we calculate the exact partition function of the length extension of a discrete extensible wormlike polymer under a stretching force. The bond's extensibility is modeled with harmonic springs, and the links present the transversal bending recoil typical of the wormlike chain (WLC) model. The evaluation has followed two methods: From the one hand by using the Transfer Matrix procedure to calculate numerically the extension/force curve of the polymer, whose outcomes have been double checked with numerical experiments given by Langevin simulations. On the other hand, by calculating some approximated analytical extension/force functions, the most accurate at the date, that can reproduce with high precision the numerical curves also at low values of the longitudinal elastic constant where the common phenomenological proposals differ considerably.

Aula F4 - Henrietta Leavitt **ore 15:10 – 19:30**

Sezione III
Astrofisica
Presiede: De Lucia G. (INAF, Trieste)

Relazioni su invito

▲ **Einstein Telescope science and synergy with electromagnetic observatories.**
Branchesi M.
Gran Sasso Science Institute, L'Aquila
The Einstein Telescope (ET) is the next-generation GW observatory, which will allow us for the first time to probe the Universe throughout its cosmic history all the way back to the dark ages. ET will be an unprecedented resource for addressing open questions in fundamental physics, astrophysics and cosmology. It will probe physics near the black hole (BH) horizon, help understand the nature of dark energy and possible modifications of general relativity on cosmological scales. ET will provide access to the entire population of stellar and intermediate-mass BHs, allowing us to understand their origin, evolution, and demography. It will probe fundamental forces in the interiors of neutron stars enabling new investigation into the properties of nuclear matter. ET will operate in synergy with innovative electromagnetic observatories, such as CTA, the Vera Rubin Observatory, ELT, and new high-energy satellites such as THESEUS and HERMES making it possibile to investigate compact objects in connection with kilonovae and short gamma-ray bursts. The talk will give an overview of the ET scientific perspectives considering different designs.

Comunicazioni

● **Simultaneous estimation of chirp-mass and Keplerian eccentricity from Time-Frequency representations of chirping gravitational waves.**
Fusco A. ([1])([2]), Pinto I.M. ([3]), Addesso P. ([4])
([1]) *CNR-IREA, Napoli, Italy*
([2]) *University of Sannio, Benevento, Italy*
([3]) *Retired professor, University of Naples Federico II, INFN, OPTICA Fellow*
([4]) *Dept. of Information Engineering, University of Salerno, Italy*
Time/Frequency (T/F) representations are a powerful and versatile tool for handling non-stationary signals, including the chirping gravitational waves produced by inspiraling binary systems. Recent improvements in T/F representations, based in particular on the compressed-sensing paradigm, allow the simultaneous estimation of the source Keplerian chirp-mass and orbital eccentricity (at some reference time) by straightforward re-mapping of the T/F data into the chirp-mass/eccentricity plane. The accuracy of the proposed T/F method, and its robustness against non-ideal background-noise features, are demonstrated by numerical simulations.

● **Using low energy electrons to neutralizing electrostatic charges on cryogenic test mass mirrors of future gravitational wave detectors.**
Spallino L., Angelucci M., Cimino R.
LNF-INFN, Frascati, RM, Italy
Electrostatic charging is a limiting noise source for gravitational wave detectors (GWD) already at room temperature. Integrating the current mitigation method is impossible at

cryogenic temperature since a significantly thick condensed N2 layer will develop on the mirror surface, severely affecting detection operations. The development of a new technology to mitigate electrostatic charging at cryogenic temperature is then urgent to preserve the performances envisaged by future GWD. Here we present a novel mitigation method compatible with cryogenics. By performing electrostatic measurements on a Si substrate, we show how to neutralize both a positive and negative charge by properly tuning the energy of an electron beam impinging on the sample surface. A study of irradiation parameters is given, highlighting the strict correlation between the surface voltage, monitored during the neutralization process, and the secondary electron emission properties intrinsic of the material. Preliminary XPS and Raman investigations have shown that, within the detectability limit, electron irradiation below few hundreds eV does not induce observable structural defects on the substrate.

Relazioni su invito

▲ **Virgo: achieved results, status and perspectives.**
Fafone V.
Università degli Studi di Roma Tor Vergata e INFN Roma Tor Vergata
After the three observing runs (O1, O2 and O3), the gravitational wave network is moving toward a new observational campaign. This talk will present an overview of the main scientific results obtained so far, along with a summary of the present status of the detector, the perspectives for the next observing runs O4 and O5, and the longer-term development plans.

Comunicazioni

● **The targeted search for continuous gravitational waves in LIGO/Virgo data.**
D'Onofrio L.
INFN Napoli
I review the latest results by the LIGO-Virgo-Kagra Collaboration for the targeted search of continuous gravitational waves (CWs) from known pulsars. First, I present an overview of the types of the CW search. Then, I show the results obtained using data from the third observing run of LIGO and Virgo detectors combined with data from the second observing run. No evidence of gravitational waves has been found but it is possible to set upper limits on the CW amplitude and on the pulsar ellipticity at 95% confidence level. 23 of the analyzed pulsars have strain amplitudes that are lower than the limits calculated from their electromagnetically measured spin-down rates.

● **Meeting advanced Virgo/LIGO requirements with ternary coatings.**
Pierro V. ([1]), Pinto I.M. ([2]), Granata M ([3]), Sassolas B. ([3]), Demos N. ([4]), Gras S. ([4])
([1]) *Dept. of Engineering, DING, Univ. of Sannio, Benevento, Italy*
([2]) *Retired professor, University of Naples Federico II, INFN, Optica Fellow*
([3]) *CNRS-INFN Laboratoire Materiaux Avancees, Lyon, France*
([4]) *Massachusetts Institute of Technology, LIGO Group, Boston MA, USA*
The dielectric mirrors laid on the test masses terminating the optical cavities of interferometric detectors of gravitational waves are a key component of these instruments, setting their visibility distance in the core spectral band from tens to hundreds of Hz, in view of their Brownian noise level. The use of three or more coating materials, downselected from a meaningful pool of available ones, and the development of efficient multi-objective optimization

engines, allow to meet all design goals (transmittance, absorbance, noise) of next generation gravitational wave detectors. Candidate materials, design algorithms, sample simulations, coating protypes and measurements will be presented and discussed.

● **Recent results on de Broglie gravitational waves.**
Feoli A. ([1]), D'Errico L. ([2]), Benedetto E. ([1])([3])
([1]) *University of Sannio*
([2]) *Indipendent reasercher, Lindau, Bodensee, Germany*
([3]) *University of Salerno*
Twenty-five years ago Feoli and Scarpetta found a particular solution of Einstein's linearized equations with some properties in common with the de Broglie waves of quantum mechanics. In particular, this kind of waves can be associated with a massive particle moving at constant velocity in agreement with the original idea of de Broglie. The group velocity of the wave is the same as the source particle, that can be interpreted as whatever quantum particle or even as a massive graviton. We briefly review the first results obtained on this subject some years ago, and we will show some new developments about the study of the polarization states, the motion of a sphere of test particles in the field of the wave and the corresponding radiation emitted when one of these test particles is electrically charged.

Relazioni su invito

▲ **Osservazione dei raggi cosmici da Terra.**
Cataldi G.
INFN, Sezione di Lecce
I raggi cosmici, scoperti all'inizio del ventesimo secolo, sono particelle cariche relativistiche, con uno spettro che si estende fino ad altissime energie. Possono raggiungere la Terra in provenienza da acceleratori extraterrestri ed essere osservati con apparati sperimentali dedicati fornendoci informazioni sulle loro sorgenti e sulla struttura dell'Universo. In questa relazione sono descritte le strumentazioni impiegate nella rilevazione dei raggi cosmici da Terra ed è presentata una selezione dei più recenti risultati scientifici ottenuti da alcuni esperimenti. Infine vengono mostrate le prospettive future nel campo della fisica dei raggi cosmici.

Comunicazioni

● **A balloon experiment for sub-GeV anti-deuteron identification in cosmic rays.**
Rossi F., Nozzoli F., Zuccon P.
Università degli Studi di Trento e INFN-TIFPA
The investigation of antideuterons in cosmic rays (CR) is particularly suited to probe different dark matter (DM) models. In the sub-GeV energy region the secondary antideuteron flux, produced by the interactions of primary CR with the inter-stellar medium, is kinematically suppressed. Thus, a possible sub-GeV contribution to antideuteron flux due to the annihilation of galactic DM could be investigated with a negligible astrophysical background. An innovative (circum-antarctic) balloon experiment designed to identify low-energy antideuterons is described. It consists of a 30 m^3 Time of Flight detector around a segmented pressurized helium calorimeter. The identification of stopping antideuterons relies on the formation of metastable exotic helium atoms. Particle identification is performed by combining the particle velocity, the kinetic energy and the timing information and topology of the delayed exotic helium annihilation. The performances of a possible detector design, simulated using Geant4 11.0.3 toolkit, and the results of 70–250 MeV proton beam characterization of a prototype of pressurized helium calorimeter will be shown.

An effective and predictive model for the long-term variations of Cosmic Rays in the Heliosphere.

Pelosi D., Bertucci B., Fiandrini E., Tomassetti N.
Dipartimento di Fisica, Università degli Studi di Perugia, Italia

The intensity and energy spectrum of cosmic rays in the heliosphere are influenced by the solar modulation phenomenon, which follows an 11-year cycle of solar activity. A better understanding of this process and its underlying physical mechanisms is essential for accurately assessing radiation exposure and risks during space missions. To address this, our team has developed an effective and predictive model of cosmic-ray modulation, which considers various mechanisms, such as diffusion, advection, and energy losses, to estimate the real-time evolution of cosmic radiation levels near Earth. We have calibrated and validated our model using cosmic-ray flux measurements from space-based detectors, along with observations of solar activity and interplanetary parameters. Our model has significant potential applications in space radiation monitoring and nowcasting, as it can predict exposure levels during future space missions.

Eco gas mixtures for the MRPC cosmic ray telescopes of the EEE project.

Ripoli C. on behalf of the EEE Collaboration
Physics Department University of Salerno e INFN

The Extreme Energy Events (EEE) experiment is designed to detect and study high-energy cosmic rays. The whole EEE network is composed of 61 gas filled muon telescopes based on Multigap Resistive Plate Chambers (MRPC). The use of a mixture with lower Global Warming Potential (GWP) is essential to abate Greenhouse Gas (GHG) emissions, in accordance with the project of ecological transition. After studying different eco-friendly gas mixtures suitable for the EEE detectors, an increasing number of detectors of the EEE array is presently being fluxed with a new ecological mixture made of $C_3H_2F_4$ with the addition of He or CO_2 which replaces the standard gas mixture (98% $C_2H_2F_4$ - 2% SF_6) used so far. Tests on performance and long-term data acquisition are ongoing on several EEE telescopes.

Cosmic antiprotons prediction with updated production cross sections.

D'Angelo F., Masi N., Oliva O.
INFN - Sezione di Bologna e Università di Bologna

As there are no known astrophysical sources of cosmic ray (CR) antiprotons, they represent a good channel for indirect dark matter search. The secondary antiproton background is produced in collisions between primary CRs and the interstellar medium (spallation). In the last decade, thanks to high precision measurements by AMS-02 and PAMELA, a possible tension between the observed antiproton flux and different predictive models has been highlighted, between 1 and 500 GeV in the antiproton kinetic energy. In the 10–100 GeV range, the dominant uncertainties are the production cross section ones: the pp, p-He and He-p channels are responsible for almost all the cosmic antiprotons. Using the GALPROP-HelMod environment it is possible to calculate the propagation of the cosmic antiprotons in the Galaxy and in the heliosphere. The preliminary results of the predicted antiproton spectra, with updated antiproton secondary production cross section, are shown.

Sub-MeV particle flux measurements with the Low Energy Module (LEM) onboard the NUSES platform: status and outlooks.

Nicolaidis R., Nozzoli F.
Università di Trento, Povo, Trento TN e INFN, Trento Institute of Fundamenta Physics and Applications, TIFPA, Povo, Trento TN

The NUSES space mission will host two payloads: TERZINA for Ultra High Energy Cosmic Ray (UHECR) Physics and ZIRE. The latter will measure particle fluxes, mainly elec-

trons and protons, in the range from few MeV up to several hundreds of MeV for studying hypothetical correlations between particle precipitations from van Allen Belts and seismic/volcanic activities. Moreover, statistical evidence suggests that the higher sensitivity to this correlation should be found observing electrons in the sub-MeV region of the spectrum. The Low Energy Module (LEM), an extension of the ZIRE payload, is developed for satisfying such stringent sensitivity to low energetic particles: electrons in the 0.1–7 MeV and protons in the range 3–50 MeV. The detector uses the $\Delta E - E$ technique for energy measurement and event-based particle identification (PID). Within this design, silicon detectors, in a telescopic configuration, will provide 8 channels encoding different portions of the sky with an angular resolution less than 10 degs. In this presentation, the updated geometry of the detector, new tests and characterizations, and the results from the GEANT4 simulation will be presented.

Crystal eye.

Smirnov A. ([1]), Barbato F. ([1]), De Mitri I. ([1]), Di Giovanni A. ([1]), Fernandez Alonso M. ([1]), Anastasio A. ([2]), Boiano A. ([2]), Colalillo R. ([3]), Garufi F. ([3]), Guarino F. ([3]), Vanzanella A. ([3]), Valore L. ([3]), De Asmundis R. ([2])
([1]) *Gran Sasso Science Institute, Italy*
([2]) *INFN-Napoli, Italy*
([3]) *Università di Napoli Federico II, Italy*

From recent observations it became clear that medium-low energy (*i.e.*, ∼keV-MeV) gamma-rays are powerful probes for the extreme Universe. For this reason it is necessary to design new detectors optimized for the medium-low energy range. One of the proposed novel detection techniques is the one adopted by Crystal Eye. Crystal Eye is a new all-sky monitor using an up-to-date technology that includes a wide Field Of View, a good sky localization capability and a large effective area. This detector has a configuration which allows it to catch gamma-rays from 10 keV to 30 MeV. Today the research group is working at several levels to this application: a Crystal Eye prototype for the Space Rider mission, the Crystal Eye full scale detector design and the use of the Crystal Eye detection technique in the calorimeter of the Ziré payload for the NUSES mission. In this talk, I will present the characterization and test of several scintillators. These tests provide indications to fix some parameters of Crystal Eye to optimize its design. Also, I will present some simulation results about the prototype and whole detector.

Aula P2 **ore 15:10 – 19:30**

Sezione III
Astrofisica
Presiede: Iodice E. (INAF, Osservatorio Astronomico di Capodimonte)

Relazioni su invito

▲ **Tracing Supermassive Black Holes in cosmological simulations.**
Damiano A.
Dipartimento di Fisica dell'Università di Trieste, Sez. di Astronomia, Trieste, Italy, INAF, Osservatorio Astronomico di Trieste, Trieste, Italy, INFN, Instituto Nazionale di Fisica Nucleare, Trieste, Italy e ICSC - Italian Research Center on High Performance Computing, Big Data and Quantum Computing
Supermassive black holes (SMBHs) represent one of the most mysterious topics in modern astrophysics. The feedback from active galactic nuclei (AGN) fed by SMBHs has been proposed as a major cause of the regulation and extinction of star formation rates in massive galaxies. Cosmological hydrodynamical simulations are successful tools for investigating the evolution of galaxies in a cosmological context and due to the co-evolution of BHs and host galaxies, simulations must correctly include the effect of BHs. However, the introduction of BHs into simulations runs up against numerical limitations imposed by mass and spatial resolution asking for *ad hoc* sub-resolution techniques. Recently, new methods have been developed to reproduce the dynamical friction force that binds BHs at the centre of galaxies and drives the early stages of mergers. Accurate reconstruction of BH dynamics proves to be not only a necessary ingredient to recover the AGN feedback that influences structure growth, but also a powerful tool to fully exploit the new window offered by gravitational wave astrophysics for the study of the formation and evolution of cosmic structures.

▲ **Toroidal structures in astrophysical objects: gravitational properties.**
Bannikova E.
INAF, Capodimonte Astronomical Observatory, Naples, Radio Astronomy Institute, NAS of Ukraine, Kharkiv e V.N. Karazin Kharkiv National University, Ukraine
Astrophysical objects such as ring galaxies and AGNs possess toroidal (ring) structures which require consideration for their gravitational properties. This paper reviews the results of my group for a torus with circular and elliptical cross-section and inhomogeneous density distribution. The dynamics in a field of a thin torus plus central mass shows that closed circular orbits exist only up to a certain radius, corresponding to the "outermost stable circular orbit" (OSCO), in analogy with the ISCO in the relativistic case. There is also an unstable equilibrium region, named "Lagrangian circle" (LC). The region with non-circular orbits between LC and OSCO may explain the gap in the stellar density distribution observed in ring galaxies. N-body simulations prove that gravitating torus is stable and keep its thickness. We applied this result to dusty tori in AGNs to account for recent ALMA velocity maps. We also estimated SMBH masses in Sy2 galaxies, taking into account more complicated dynamics in the torus than in the disk. The gravitational lensing effects on the system of a central mass plus a ring demonstrate that the formation of three Einstein rings is possible.

▲ **KM3NeT: Physics results and update on the construction plan.**

Biagi S.
INFN, Laboratori Nazionali del Sud, Catania, Italy

KM3NeT is a multi-site detector devoted to the detection and study of cosmic neutrinos and their sources in the Universe, and to the measurement of the neutrino oscillation parameters. Two underwater detectors are under construction in the Mediterranean Sea, ARCA (Portopalo di Capo Passero, Italy) and ORCA (Toulon, France), optimized, respectively, for neutrinos in the energy range of 1 TeV–100 PeV and 10 GeV–10 TeV. A long-term plan for the completion of both detectors is in place. Currently, 21 (14) Detection Units are active in the ARCA (ORCA) site. In this communication I will report the main physics results obtained with ARCA and ORCA, in their partial configurations, and an overview of the expected performances of the full detectors will be given. The main technological efforts carried on in the last years will be described, which paved the way to the current mass construction phase.

Comunicazioni

● **Active Galactic Nuclei as probes of Relativistic Thermodynamics.**

Antonuccio-Delogu V.
INAF-Catania Astrophysical Observatory, Italy

More than 110 years after the introduction of Special Relativity, Relativistic Thermodynamics (hereafter RT) has not yet been put on firm grounds. The issue is often exemplified by the question concerning how the temperature of a moving body having a rest frame temperature T_0 transforms with the observed body's speed: will temperature transform linearly with the Lorentz factor or its inverse, *i.e.*, will a moving body appear hotter or colder (see Ott, 1963 and Einstein, 1907)? Or instead is temperature a relativistic invariant (Landsberg, 1968)? Within an astrophysical context the environment of Active Galactic Nuclei (AGNs) provides two ideal sites where matter moves at relativistic velocities and thus RT could be probed: the plunging region of an accretion disc, beyond the *Innermost Stable Circular Orbit*, and the Interstellar/Intracluster Medium where the jet interacts with the cold, star-forming clouds. We compare the predictions from different recently proposed RT theoretical models concerning different emission lines and properties, demonstrating how one could exploit AGNs and their relativistic jets as probes of RT, one of the last open issues in Relativity.

● **The impact of gravitational lensing in the reconstruction of stellar orbits around Sgr A*.**

Pietroni S.
INAF-OACN, Napoli

After the amazing discoveries by the GRAVITY collaboration in the last few years on the star S2 orbiting the black hole Sgr A* in the center of the Milky Way, we present a detailed investigation of the impact of gravitational lensing on the reconstruction of stellar orbits around this massive black hole. We evaluate the lensing astrometric effects on the stars S2, S38 and S55 and how these systematically affect the derived orbital parameters. The effect is below current uncertainties, but not negligible. With the addition of more observations on these stars, it will be possible to let the astrometric shift by lensing emerge from the statistical noise and be finally detected. By repeating the analysis on a smaller semimajor axis a and various inclinations i, we are able to quantify the lensing effects on a broader range of parameters. As expected, for smaller semimajor axes and for nearly edge-on orbits lensing effects increase by about an order of magnitude.

Decoding a black hole metric from the interferometric pattern of relativistic images of a compact source.

Aratore F., Bozza V.
Università degli Studi di Salerno

Gravitational Lensing is the effect for which light rays are deflected by a gravitational field. In presence of a black hole acting as a lens, photons can wind several times around it before fleeing towards the observer. This creates two infinite sequences of images of a given source with decreasing magnitude, asymptotically approaching the border of a zone that will remain obscure called shadow. The features of these images are reflected by a characteristic staircase structure in the complex visibility function. Recalling the formalism of the strong deflection limit, we derive analytical formulae for the height, the width, and the periodicities of the steps in the visibility function that can be inverted to determine the metric coefficients, distance and size of the source starting from the images pattern. With respect to diffuse emission by the whole accretion flow, this ideal framework provides clean insight and model-independent information on the metric. Moreover, these formulae can track the changes induced by orbital motion of the source or alternative metrics and ultimately test General Relativity.

Plasma structures of astrophysical jets unraveled.

Coppi P.S. ([1]), Coppi B. ([2])
([1]) *Department of Physics, Yale University, CT, USA*
([2]) *MIT, Cambridge, MA, USA*

The theoretical finding of plasma structures propagating away from disks associated with binary systems has led to propose that an important class of the jets observed in astrophysics are the results of the emission of these structures. Double-helix structures were in fact identified, in one case, as a result of non-linear interactions of modes excited in circumbinary disks sustained by pairs of stellar black holes. The other considered case is that of a massive black hole paired with a much lighter "sheperd" black hole that is proposed to be relevant to an important class of observed jets. According to the theory, the emitted plasma structures are associated with the fluctuations generated by the carving of a "swept torus" by the sheperd black hole in the plasma disk sustained by the main black hole. In fact, a following analysis of the observed M87 Jet structure had led to conclude that this was of a double-helix kind. More recent studies of other jets associated with massive black holes have identified helical or different plasmas structures associated with them.

Development of an open-source code for the modelling of hadronic emission processes in the jets of active galactic nuclei.

Maniadakis D. ([1]), Bernardini E. ([1]), Viale I. ([1]), Nigro C. ([2]), Sitarek J. ([3])
([1]) *Dipartimento di Fisica, Università di Padova, Italia*
([2]) *Institut de Fisìca d'Altes Energies, The Barcelona Institute of Science and Technology, Spain*
([3]) *Department of Astrophysics, Faculty of Physics and Applied Informatics, University of Lodz, Poland*

AGNpy is an open-source Python package for modelling the radiation of the relativistic jets of active galactic nuclei whose spectral energy distribution can be explained by both leptonic and hadronic emission processes. Even though the presence of highly energetic electrons and positrons is quite certain, the multi-messenger observation of a neutrino associated with a flaring blazar in 2017 suggests the presence of accelerated protons alongside leptons in the jet, as neutrinos can only result from hadronic processes. Considering these facts and the very existence of cosmic rays, we expanded AGNpy's capabilities from its previous state of

a fully leptonic code to a lepto-hadronic code. We incorporated two of the most significant hadronic processes that occur in the jet: the synchrotron radiation originating from protons and the photo-meson production, the latter being the primary process responsible for the neutrino emission in the jet. As it stands, AGNpy will be the first open-source software for modelling the radiation of relativistic jets of active galactic nuclei that includes hadronic emission processes.

ULISSE: a tool for one-shot sky exploration and its application to Active Galactic Nuclei detection.

Cavuoti S. ([1])([2]), Doorenbos L. ([3]), Torbaniuk O. ([4])([5]), Paolillo M. ([1])([2])([4]), Longo G. ([4]), Brescia M. ([4]), Sznitman R. ([3]), Márquez-Neila P. ([3])
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Since modern sky surveys generate increasingly large amounts of data, traditional methods for classifying and analyzing objects become more difficult and time-consuming. However, the use of automatic machine and deep learning methods can help to address this issue. We have developed a new deep learning tool called ULISSE (aUtomatic Lightweight Intelligent System for Sky Exploration) that can identify objects with similar morphological and photometric properties to a single prototype object, creating a list of candidate lookalikes. We demonstrate the use of ULISSE in detecting Active Galactic Nuclei (AGN) candidates in a Sloan Digital Sky Survey galaxy sample, as identifying and classifying AGN in the optical band remains challenging. ULISSE uses features derived to classify the ImageNet dataset to perform similarity searches without time-consuming neural network training. This allows for rapid identification of candidates from a single image of a prototype. Our results suggest that ULISSE could be a valuable tool for selecting various astrophysical objects in current and future wide-field surveys such as Euclid and LSST that will target millions of sources every single night.

Application of deep learning to early detection of compact binaries by ground-based detectors.

Papalini L., Razzano M.
University of Pisa e INFN Pisa

Multimessenger astronomy is a new way of exploring the Universe. This research area aims to combine signals from distinct sources. An example is binary neutron star coalescences, which emit both gravitational waves and electromagnetic emissions. However, current detection algorithms cannot guarantee prompt localization from the gravitational signal due to the amount of data involved. Therefore, this work aims at building a novel early warning pipeline for binary neutron star gravitational signals based on deep neural networks. Deep learning is a promising tool for fast processing of significant amounts of data. The architecture implemented for this work is a 1D Convolutional Neural Network that performs predictions on interferometers' strain time series and distinguishes between binary neutron star inspiral and transient noises. It comprises three convolutional layers and one final dense layer. It is trained on LIGO-Livingston custom simulations of signals embedded in a realistic and coloured noise. The final accuracy reached from the network is ca. 80. Results show that deep learning is a viable approach to tackle the problem of early warning.

"Fast" modeling procedures for the characterization of Supernova events from H-rich progenitors.

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The supernova explosion (SNe) from a hydrogen (H) rich star is a catastrophic event that leads to the expulsion of the outer H-rich stellar layers (with a kinetic energy of the order of 10^{51} ergs), and to the formation of a compact object such as a Black Hole or a Neutron Star. Although the explosion mechanism is well established, there are still no systematic studies on the physical properties that regulate these events. The uncertainties about the explosion parameters and the nature of their progenitors have numerous repercussions in various fields of astrophysics, ranging from cosmology to multi-messenger astronomy. The launch of future dedicated surveys (such as the Legacy Survey of Space and Time, LSST) is going to open the possibility to observe thousands of H-rich SNe per year, for these reasons, our group is developing rapid modeling procedures, in order to characterize large samples of SNe in a sufficiently accurate way. The validation and application of these procedures were carried out on supernovae similar to SN1987A. The results of these preliminary analyses and the modeling procedures for other types of H-rich SNe and similar transients will be presented.

Modelling of early-stage kilonova ejecta opacity reproducible in laboratory plasmas.

Bezmalinovich M. ([1])([2])([3]), Cristallo S. ([2])([3]), Emma G. ([4]), Finocchiaro G. ([4])([5]), Mauro G.S. ([4]), Mazzaglia M. ([4]), Mishra B. ([4])([5]), Naselli E. ([4]), Pidatella A. ([4]), Santonocito D. ([4]), Torrisi G. ([4]), Vescovi D. ([2])([3]), Mascali D. ([4])([5])
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A complete understanding of heavy elements nucleosynthesis is crucial in the framework of the multi-messenger astronomy. This led astrophysicists to investigate the KN (kilonova) emission, a thermal transient strongly dependent on opacity and freshly synthesized elements by the rapid neutron capture process (r-process). Modelling the KN light-curve is challenging: besides the difficulties in modelling the r-process, it requires several inputs, among which opacities are still extremely uncertain. In this context, the PANDORA (Plasma for Astrophysics Nuclear Decay Observation and Radiation for Archaeometry) project aims at measuring, for the first time, plasma opacities from an ECR (Electron Cyclotron Resonance) plasma resembling the theoretical KN ejecta. Thereby, relevant results can be achieved in order to shed light and bridge the gap between theoretical predictions and observations. Here, we present numerical simulations which have been performed to estimate opacity values of a plasma made of heavy metals interesting for the early-stage KN environment. Moreover, numerical estimates of plasma opacity for selected light r-process nuclei will be presented.

Infrared detection for time-domain astronomy.

Drago A.
Università di Firenze, Dipartimento di Fisica e Astrofisica e INFN/LNF
The GW170817 event from the merger of two neutron stars and the simultaneous electromagnetic detection opened a new era in multi-messenger astronomy. GRB (Gamma Ray Burst) and FRB (Fast Radio Burst) are other fast transient phenomena observed. Looking to a more general point of view, it can be useful to develop the time-domain astronomy,

that asks for specialized types of detectors. Astronomical fast events, burst or transients, lasting between 1 s and 1 ns, fall in the field of time-domain astronomy. For the photon detection, the technologies change for the observation of remote sources in different regions of the electromagnetic spectrum. In order to design a new type of astronomical detector in the mid infrared, the experience done for the storage ring diagnostics can be useful. In the jargon of accelerator physics, diagnostic devices integrating over time are called transversal while those acquiring in time-domain are called longitudinal (where the phase is referred to the master clock). A longitudinal detection system for astronomical observations at ground level or for scientific balloon is under study at SINBAD, the IR light beam line of DAFNE, the e^+/e^- collider of INFN.

Studying the variability in Fermi-LAT gamma-ray pulsars around glitches.

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Pulsars are the largest class of Galactic sources detected by NASA's Large Area Telescope (LAT) on the Fermi mission. Pulsars are generally acknowledged as very stable astrophysical rotators, and they gradually slow down by emitting radiation at the expense of their rotational energy. Occasionally, pulsars can undergo transient events called glitches, which consist in rapid changes in their rotational parameters and are often followed by a relaxation. Variability in the emission features correlated to glitches has been observed in a small family of radio pulsars and in the radio-quiet PSR J2021+4026, which is the only variable pulsar observed by the LAT. Here we present a novel analysis of LAT gamma-ray pulsars consisting of a study of variability correlated with changes in the spin-down rate. We perform a maximum likelihood spectral analysis of LAT data around detected glitches, aiming at measuring variations in the gamma-ray flux and spectral parameters. We present results for a subset of glitches that we consider particularly promising. Our study suggests the importance of variability analysis to achieve a deeper understanding of pulsar physics.

Non-linear electrodynamics in Blandford-Znajeck energy extraction.

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Non-linear electrodynamics (NLED) is a generalization of Maxwell's electrodynamics for strong fields. It could have significant implications for the study of black holes and cosmology and has been extensively studied in the literature, extending from quantum to cosmological contexts. Recently, its application to black holes, inflation and dark energy has caught on, being able to provide an accelerated Universe and address some current theoretical inconsistencies, such as the Big Bang singularity. In this work, we report two new ways to investigate these non-linear theories. First, we have analyzed the Blandford-Znajeck mechanism in light of this promising theoretical context, providing the general form of the extracted power up to second order in the black hole spin parameter. We have found that the emitted power can be extremely increased or decreased, and that the magnetic field lines around the black hole seems to become vertical quickly and that no monopole solutions exist. Our (analytical) results emphasize that the existence and behavior of NLED strongly depends on the model and that only a power-law model seems to have any chance to compete with Maxwell.

First study of 4U 1820-303 polarization in the X-ray band.
La Monaca F. on behalf of the IXPE Science Collaboration
INAF - Istituto di Astrofisica e Planetologia Spaziali
4U 1820-303 was the first identified source of type I X-ray bursts, it is an ultracompact Low Mass X-Ray Binary consisting of a neutron star accreting matter via Roche lobe overflow from a He white dwarf, located at $\sim 0.66''$ from the center of the globular cluster NGC 6624. Here, we present the first polarization measurement in the X-ray band, obtained thanks to the Imaging X-ray Polarimetry Explorer. We also obtained simultaneous observations with Swift-XRT, NICER, and NuSTAR, aiming to obtain an accurate X-ray spectral model covering a broad energy interval and with ATCA to measure the polarization in Radio.

4D cosmological consequences of Brans-Dicke theory from 5D scalar vacuum.
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$5D$ Brans-Dicke (BD) theory is discussed in the framework of (gravitational) baryogenesis and primordial light element formation. Such a cosmological model could represent a suitable scheme to explain the present cosmic accelerated expansion without recurring to matter fields in $5D$ or dark energy in $4D$ if one assumes the scheme of Kaluza-Klein induced-matter theory. In this approach after the $5D$ to $4D$ reduction, a space-matter tensor related with BD-scalar field and higher-dimensional counter-terms arises on shell playing the role of a new ingredient on the four-dimensional hypersurfaces orthogonal to the extra coordinate. Since the FRW cosmological equations admit a power law solution of the scale factor, $a(t) \sim t^{\alpha}$, one can constrain the exponential factor α by using the present bounds on the matter-antimatter asymmetry in the Universe and Big Bang Nucleosyntheis (BBN). A possible connection with Dark Matter relic abundance is also discussed.

Interplay between asymptotic safe gravity and generalized Proca theories.
Rufrano Aliberti S. ([1]), Lambiase G. ([1]), Heisenberg L. ([2]), Platania A. ([3])
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Asymptotic safety gives the chance to extend to the ultraviolet regime an effective field theory, as an exap. After studying this quantum field theory paradigm applied to quantum gravity, we studied if an asymptotic safety to generalized Proca theories is possible, since they have important cosmological implications.

Aula F3 - Maria Telkes **ore 15:10 – 19:30**

Sezione IV
Geofisica e fisica dell'ambiente
Presiede: Avallone A. (INGV)

Relazioni su invito

▲ **Deep Electrical Resistivity Tomography for geophysical investigations: State-of-the-art and future directions.**
Lapenna V. ([1]), Balasco M. ([1]), Rizzo E. ([1])([2]), Telesca L. ([1])
([1]) *Istituto di Metodologie per l'Analisi Ambientale del CNR, Tito Scalo, PZ, Italy*
([2]) *Dipartimento di Fisica e Scienze della Terra, Università di Ferrara, Italy*
Electrical Resistivity Tomography (ERT) is a robust method largely applied in near-surface geophysics. Nevertheless, the mapping of the resistivity patterns at a depth greater than 1 km was performed in just a few cases by the ERT method, called Deep ERT (DERT). Information on the electrical properties of the rocks beyond $\sim$ 1 km depth has been obtained only from direct soundings or passive electromagnetic measurements (*e.g.*, Magnetotelluric-MT) so far. In this communication, a critical review of the limits and the advantages related to the recent applications of the DERT method in the geophysical exploration is discussed. The study focuses both on the purely methodological aspects (*e.g.*, 4D tomographic algorithms) and on the technological features (*e.g.*, multi-array systems). Great attention has been devoted to the novel applications of the AI-based methods and machine learning for geoelectrical data processing. The results of this review envisage the possibility to use the DERT method for studying a wide spectrum of geophysical problems that are still unsolved and/or poorly studied, from the detection of fluid migration in fault systems to the mapping of ice sheet in polar regions.

▲ **Clay landslide movement triggered by artificial vibrations: New insights from monitoring data.**
Revellino P. ([2]), Guerriero L. ([1]), Maresca R. ([2]), Guadagno F.M. ([2])
([1]) *Department of Earth, Environmental and Resource Sciences, Federico II University of Naples, Monte Sant'Angelo Campus, Naples, Italy*
([2]) *Department of Science and Technology, University of Sannio, Benevento, Italy*
Slope stability is influenced by a number of factors that modify the resisting/acting force ratio control landslide initiation and movement velocity. Among these, artificial vibrations have been identified as an important degrading factor for soil strength, but it is not fully clear if they can trigger or modulate movements of clay landslides. To contribute to a better understanding of the potential effect of vibrations on landslide movement, monitoring data acquired by a seismic station at the toe of the Pietrafitta landslide were analyzed. The landslide adjoins the SS87 national road that suffered periodic closure due to landslide activity and in April 2016 operated in the daytime only for risk mitigation purpose. This condition promoted a better identification of a potential cause-effect relation between traffic vibration and landslide movement. Results suggest that in condition of incipient movement, artificial vibrations, also of limited amplitude, are able to directly initiate clay landslide movement that, due to the viscous nature of the involved material, exhibits a specific displacement pattern that is not consistent with a sliding block model.

▲ **Resources and potential for geothermal energy in Italy.**

Scarpa R.
Dipartimento di Fisica, Università di Salerno, Italia

Italian geothermal resources, aimed at the production of electricity, have so far been developed above all in Tuscany, through about forty medium- and small-sized plants which currently deliver a power of 915.8 MW, producing 5.9 TWh a year, corresponding to just 5% of the RES used in Italy. The electricity that can be produced from Italian geothermal potential is 200 TWh, corresponding to 60% of the gross domestic consumption of electricity in Italy (329 TWh in 2015). The main technologies used in Italy are: i) The use of conventional plants for the production of electricity through total re-injection of fluids and ORC plants at a depth of 3–5 km. ii) The use of district heating and cooling systems with boreholes of up to 3 km. iii) Geoexchange plants for cooling and heating with shallow (< 400 m) drilling. The forecasts for the production of electricity and renewable heating and cooling systems are of a tripling by 2050, especially trying to remove the obstacles in bureaucracy and communication, which have so far slowed down the use of this relevant energy source. The objective of this communication is to present new methodologies for the diffusion of this energy with zero environmental impact.

Comunicazioni

● **Coniugazione di fase per l'esplorazione del sottosuolo.**

Valli F.
Ispra, Roma

Comparazione e sintesi dei principali metodi, ad oggi usati "anno 2023" per l'esplorazione, l'indagine e l'analisi di dettaglio del sottosuolo. Si propone un sistema avanzato di ricerca basato sulla coniugazione di fase.

● **Geophysical characterization of the Nirano Salse (Fiorano Modenese, Italy): A discussion on the possible explanation for the observed extremely low resistive values.**

Patella D. ([1]), Romano G. ([1]), Antonellini M. ([2]), Siniscalchi A. ([1]), Tallarico A. ([1]), Tripaldi S. ([1]), Piombo A. ([3])
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([2]) *Dipartimento di Scienze Biologiche, Geologiche e Ambientali, ALMA MATER STUDIORUM - Università di Bologna, Bologna, Italy*
([3]) *Dipartimento di Fisica e Astronomia "Augusto Righi", ALMA MATER STUDIORUM - Università di Bologna, Bologna, Italy*

Mud volcanoes are fluid escape structures allowing for surface venting of hydrocarbons and water/sediment slurries. For a better understanding of mud volcanoes dynamics, the characterization of the fluid dynamics within mud volcanoes conduits, the presence, extent, and depth of the fluid reservoirs as well as the connection among aquifers, conduits, and mud reservoirs play a key role. We present the results of a geoelectrical survey performed in the Regional Nature Reserve of the Nirano Salse, aimed to image the resistivity structure of the subsoil down to a depth of 250 m. The electrical models show the presence of shallow reservoirs, that are spatially coincident with the main fault/fracture controlling the migration routes associated with surface venting and converge at depth towards a common clayey horizon. In the geoelectrical sections, conductive zones can be associated to fluid accumulation areas. Fluid presence, however, is not sufficient to justify the extremely low resistivity values observed. We suggest that these values may be associated with i) clay content and surface

conductivity phase and/or ii) presence of iron sulphides due to precipitation of hydrogen sulphide.

Remote sensing techniques applied to the stability analysis of the Calitri landslide (southern Italy).

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([1]) *Department of Earth Sciences, Environment and Resources, Federico II, University of Naples*
([2]) *National Institute of Geophysics and Volcanology, National Earthquake Observatory, Grottaminarda, Italy*

Regular and continuous monitoring is required for the prevention and mitigation of a variety of instability phenomena: it provides solutions to mitigate and minimize disaster losses and the hazard to human life. The objective is to verify the suitability of remote sensing methods as complementary tools for monitoring slow-moving landslides. By comparing interferometric and GNSS results with conventional ground-based data, we aim to improve stability studies of the Calitri landslide. Calitri, a town in the Avellino province, is located within the Campanian segment of the southern Apennine chain on the left side of the Ofanto river and, since historical time, its southern slope has been affected by a large roto-translational landslide that evolved into an earthflow. The last reactivation occurred after the main shock of the Campania-Basilicata earthquake (November 23, 1980, Mw $= 6,9$) and it mobilized the silty and marly clays and sands of Ruvo del Monte and Andretta synthem. We will illustrate the integration of the GNSS RING network with the creation of an *ad hoc* network and the analysis of interferometric data (C and X bands) to obtain a complete view of the kinematics in place.

Detailed study of the recent seismicity of the Nesjavellir (Iceland) geothermal production area.

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([2]) *Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Vesuviano, Napoli, Italy*
([3]) *Dipartimento di Scienze e Tecnologie, Università degli Studi del Sannio, Benevento Italy*
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The Nesjavellir geothermal field is located in South West Iceland, in the northern section of the Hengill central volcano. OR-Reykjavik Energy now produces electricity and hot water for district heating at two power plants in the Hengill area. Seismicity in the area has been interpreted as a result of volcano-tectonic processes, natural geothermal activity, and geothermal operations. The goal of the study is to achieve a better knowledge of the mechanisms that cause seismicity by studying the properties of the medium and the kinematic characteristics of earthquakes. At shallow depths below Nesjavellir, low V_p/V_s ratios and low b-values are estimated. Between 3.5 and 6 km depths, high V_p/V_s ratios and high b-values are detected in correspondence of the deepest seismicity, which is characterized by a higher number of small events. Our results point to the coexistence of various processes that regulate seismicity. We are able to observe the space-time evolution of seismicity and the related variation in elastic media properties, through 4D analysis. This work has been supported by PRIN-2017 MATISSE project, No. 20177EPPN2, funded by Italian Ministry of Education and Research.

A statistical elaboration of multiple observations from a geophysical monitoring network.

Fidani C.

INGV, Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italy and CIEN, Central Italy Electromagnetic Network, Fermo, Italy

The conditional probability of an exceptional event such as an earthquake can be defined through the variations of one of the geophysical observables that usually precede it. Starting from the frequencies of seismic events above a certain magnitude and the variation of an observable that exceeds its threshold, the probability gain of an earthquake is linked to the correlation between the two events. Some examples are discussed where observations made both from satellite, using MEPED onboard NOAA, and on the Earth's surface by ULF magnetic detectors produce probability gains around 4. The same approach is extended to multiple observations both from the ground and from satellites, considering not completely independent observables, where the probability gains are calculated for both distinguishable and indistinguishable observables. An example is also discussed in this case, showing how the overall probability gain increases and depends on the comparison volume of the observables. Finally, the probability gain is estimated by using a network of geophysical monitoring instruments.

Unravelling the electrical structure in a sector of the Irpinia fault with a 3D magnetotelluric investigation.

Balasco M. ([1]), De Girolamo M. ([2]), Romano G. ([3]), Siniscalchi A. ([3]), Ventola I. ([3])

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([2]) *Istituto di Geofisica e Vulcanologia, INGV, Roma*

([3]) *Università degli Studi di Bari*

In conjunction with the the DEnse mulTi-paramEtriC observations and 4D high resoluTion imaging (DETECT) experiment, n. 30 broad-band magnetotelluric (MT) soundings were carried out between 2007 and 2022 obtaining impedance tensor estimates in the period range for 10^{-1} to $3 \times 10^{+3}$ s. These soundings covering a wide sector (80×60 km) of the Irpinia fault system, which generated the largest Italian event in the last 100 years with Ms = 6.9 (1980). Mefite d'Ansanto, the largest source of natural CO_2 gas emission measured on the Earth in a non-volcanic environment, also falls in the investigated area. In this communication we show the three-dimensional (3D) resistivity model of the survey area aimed to infer valuable information on the deep structures and processes taking place into the subsoil. This will be possible thanks to the combined high investigation depth of the MT method and its sensitivity to lateral and vertical electrical conductivity variations related to fluids presence and/or temperature changes. The model interpretation will also benefit from the integration with other geophysical (mainly seismic) observations.

Aula F7 - Giovanna Mayr **ore 15:10 – 19:30**

Sezione V

Biofisica e fisica medica

Presiede: Croci S. (Università di Parma e INFN, TIFPA, Trento)

Relazioni su invito

▲ **Model-based image reconstruction for super-resolution photo-thermal imaging.**

Bouzin M., Marini M., Sironi L., D'Alfonso L., Chirico G., Collini M., Presotto L.

Dipartimento di Fisica, Università degli Studi di Milano-Bicocca, Milano, Italia

Super-Resolution (SR) far-field optical microscopy has revolutionized the quantitative inspection of biological samples by shedding light onto details of the cellular architecture that were previously inaccessible by diffraction-limited imaging. Similarly, SR methods can be exploited to broaden the applicability of imaging modalities operating beyond the visible range. Here we focus on label-free photo-activated thermal imaging and describe the conceptualization and experimental validation of a novel SR imaging approach in the far-infrared. We exploit the photo-thermal effect primed by the absorption of raster-scanned focused visible laser light and the detection of the resulting temperature variations by a microbolometer thermal camera. Based on a full-wave modeling of heat diffusion, we reconstruct the distribution of photo-thermal endogenous entities at tunable sub-diffraction < 5 μm spatial resolution. By significantly enhancing the mm-sized conventional resolution of infrared thermography, our results expand the applicability of quantitative photo-thermal imaging to the micro-scale characterization of the homogeneity, morphology and functional state of biological samples.

▲ **Methods to characterize and interact with networks of the human brain.**

Marzetti L., Pizzella V.

Institute for Advanced Biomedical Technologies, Department of Neuroscience, Imaging and Clinical Sciences, University of Chieti-Pescara, Chieti, Italy

In the last decades, neuroscience has provided evidence for the dependence of human cognition and behavior on the formation of neuronal networks that link distributed brain regions. In this framework, physics applied to neuroscience significantly contributed to the development of technology as well as methods to characterize such neural networks from neuroimaging and electrophysiological data. In this talk, I will first present novel multidimensional methods to disclose brain network dynamics at temporal frequencies of behavior [1–100 Hz]. Emphasis will be put on linear and non-linear methods to characterize interactions occurring at the same frequency or at different frequencies, respectively. The second part of the talk will be devoted to presenting a novel multi locus transcranial magnetic stimulation device with two major characteristics: i) a spatial coverage that allows for stimulation of brain networks, other than single brain regions; ii) a stimulation with a flexible dynamics, based on real-time control signals from concurrent electroencephalography.

▲ **Measuring metabolism across scales.**

Maulucci G., Bianchetti G., Abeltino A., Serantoni C., Riente A., De Spirito M.

Department of Neuroscience, Metabolic Intelligence Lab, Università Cattolica del Sacro Cuore, Rome, IT

Metabolism is a complex and interconnected process that involves numerous biochemical reactions and pathways, transforming energy from one form to another and regulating nutrient

intake to maintain the living state of cells and organisms. To study metabolic physiology, we need to consider dynamic processes that occur over different scales of time and space. Investigating the connection between metabolism and diseases requires a multifaceted approach that examines how metabolism integrates with molecules, organelles, cells, tissues, and organisms. Therefore, measuring, mapping, and integrating metabolism across various scales and systems is crucial to comprehending human physiology and finding treatments for various diseases. The combination of Metabolic Imaging and Metabolic Modeling techniques allow to understand holistically the metabolism of living systems, from cells to organisms, relying on the latest technological advances in artificial intelligence and microscopy in order to unlock the mysteries behind metabolic processes.

Comunicazioni

Stimulated emission depletion (STED) and fluorescence lifetime microscopy (FLIM) for studying GABAA receptor subunits' response to antisecretory factor.

Angeli E. ([1]), Bazzurro V. ([1]), Gatta E. ([1]), Angeli E. ([1]), Cupello A. ([1]), Lange S. ([2])([3]), Jennische E. ([4]), Robello M. ([1]), Diaspro A. ([1])([5])
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([2]) *Department of Infectious Diseases, Institute of Biomedicine, University of Gothenburg, Gothenburg, Sweden*
([3]) *Region Västra Götaland, Department of Clinical Microbiology, Sahlgrenska University Hospital, Gothenburg, Sweden*
([4]) *Department of Medical Biochemistry and Cell Biology, Institute of Biomedicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden*
([5]) *Nanoscopy, CHT Erzelli, Istituto Italiano di Tecnologia, Genoa, Italy*

Antisecretory Factor (AF) is a protein that inhibits intestinal hypersecretion and several inflammatory conditions, but its mechanism of action is still poorly understood. To investigate the pharmacological effects of AF on the GABAA receptor, we compared electrophysiological and super-resolution microscopy data acquired by using cerebellar granule neurons as a model and administering AF-16, a peptide obtained from the amino-terminal end of the AF protein. To map GABAA receptor subunit populations' distribution and how they respond to AF-16, we labeled α1 and α6 subunits before and after 1-hour treatment with AF-16 with an immunofluorescence-based protocol, then we acquired images combining stimulated emission depletion (STED) with fluorescence lifetime microscopy (FLIM). Here, we discuss data showing an increase in GABAA receptor responses after the treatment with AF-16, particularly in those containing the α6 subunit.

Home made epi-fluorescence microscope set-up for time lapse study of biological process.

Wanderlingh U. ([1]), Vasi S. ([1]), D'Ascola A. ([1]), Conti Nibali V. ([1]), Musotto R. ([2]), Catania M.V. ([3]), Spatuzza M. ([3])
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Astrocytes use the modulation of cellular Ca^{++} concentration for intracellular signaling. In order to observe fast cellular processes in controlled environment, we have assembled an epi-fluorescence microscope that can be fitted inside a medium size cell incubator. We have resorted to raspberry Pi and open-source tools to acquire full control on camera setting and illumination sequences. We have used python programming to control the data acquisition

and to automate the extraction of relevant physical information from image sequences. In this way we are able to capture long time lapse recording of flashing sequences by astrocytes *in vitro* at frame rates ranging from millisecond to seconds. In this contribution we will illustrate the instrument implementation and present some preliminary results on human and mouse astrocytes cell cultures.

Exploring metabolic approaches for assessing and managing diabetes-related complications.

Bianchetti G. ([1])([2]), Abeltino A. ([1]), Serantoni C. ([1])([2]), Riente A. ([1]), De Spirito M. ([1])([2]), Maulucci G. ([1])([2])

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Diabetes mellitus is a multi-factorial pathology characterized by hyperglycemia and metabolic impairments in lipid turnover. These factors may induce severe alterations in the normal morphology and functioning of the vasculature, thus resulting in the development of several complications, among which diabetic retinopathy (DR) is the largest responsible for blindness. Since DR has been strictly related to functional alterations of the blood-retinal barrier (BRB), I provided a comprehensive functional and molecular characterization of retinal pigment epithelium (RPE) cells, obtained through machine-learning–based metabolic imaging, and further comparison with lipidomic features obtained from erythrocytes of diabetic patients with diagnosed DR. The observed interesting similarities between these two systems pave the way for the application of these approaches also in clinical practice, highlighting the potential role of erythrocytes as an early biomarker as well as the importance of evaluating metabolic approaches for assessing and managing the risk of developing diabetes-related complications.

Modulation of drug efflux transporters induced by low intensity focused ultrasound.

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The blood-brain barrier (BBB) provides an obstacle to the entry of drugs into the brain. BBB is mainly constituted of endothelial cells connected by tight junctions (TJs). The TJs together with efflux pumps as the P-glycoprotein (Pgp) and the breast cancer resistance protein (BCRP) limit molecules to pass from the blood to the brain. Focused ultrasound (FUS) with microbubbles can reversibly detach TJs. However, very little is known about the effect of FUS on the expression of efflux transporters. We investigated the effects of FUS on Pgp/BRCP expressions up to 2 weeks after sonication. BBB was disrupted in 12 wild-type rats. BCRP and Pgp expressions were imaged by immunohistochemistry at 1, 3, 7 and 14 days after FUS. Our results indicate that FUS-induced BBB opening is capable of i) decreasing P-gp expression up to 3 days after sonication in both the treated and in the contralateral brain regions and is capable of ii) overexpressing BCRP up to 7 days after FUS in the sonicated regions only. Our findings may help improve FUS-aided drug delivery strategies by considering both the mechanical effect on the TJs and the regulation of P-gp and BCRP.

Personalized metabolic avatar: a data driven model of metabolism to forecast biohacking effects in diet.

Abeltino A., Bianchetti G., Serantoni C., Riente A., De Spirito M., Maulucci G.
Neuroscience, Università Cattolica del Sacro Cuore di Roma, Fondazione Policlinico Universitario "A. Gemelli" IRCSS e Metabolic Intelligence Lab, Rome, Italy

Biohacking, *i.e.*, the use of small, incremental changes for the transition to a healthier and more green diet may be an innovative solution in planning diets for medical nutrition purposes, since it introduces important physiological and ecological improvements without altering individual nutritional habits. The development of predictive metabolism models can be used to test these solutions helping people to achieve long-lasting results in pursuing a healthy lifestyle. Using new incoming neural networks, we developed the Personalized Metabolic Avatar (PMA), a replica of metabolism considering multivariate time series (Energy Balance, weight, and macronutrients). As a case study, we developed a diet generator based on biohacking and we tested it on the PMA to optimize one's health, by reducing caloric intake and environmental impact. 137 2-weeks periods were considered for the simulations. Here, a trend of decreased weight is shown ($p = 0.079$) over periods more like biohacking, confirmed from simulations, yielding statistical evidence of weight loss ($p = 4e\text{-}5$). These models have the right clue to replicate the metabolism, allowing specialists to test effects of new personalized diets.

SERS (Surface-Enhanced Raman Scattering) microscopy and Raman fingerprint in Her2 breast cancer cell-lines.

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Raman spectroscopy (RS) is a fast, non-invasive, and non-destructive method to study biological matter, counting on the inelastic scattering of light. A laser source is used to generate the scattered photons, collected by a CCD detector. Nowadays, confocal Raman microscopy with sub-micrometric resolution is common instrumentation, allowing super-resolved live imaging on biological samples. Specifically, diagnosing tumor cells is a promising application field of RS, in which a clear and unbiased identification is a challenging issue. In this frame, breast cancer study is one of the main targets of cancer research, in which early-stage diagnosis can dramatically improve the patient's prognosis. In this study, we focused on Her2 protein expression, a malignancy highly correlated breast cancer biomarker. Thus, we have measured the Raman signal of different Her2 expressing cell lines and their Her2 expression levels, by developing a Surface-Enhanced Raman Scattering (SERS) sensor of the Her2 expression. This enabled the same instrumentation to correlate Her2 expression and the biochemical composition of Her2-expressing cancer cell lines.

Machine learning analysis of Raman spectra for thyroid cancer diagnosis.

Bellantuono L. ([1])([2]), Tommasi R. ([1]), Pantaleo E. ([2])([3]), Di Gioacchino M. ([4]), Verri M. ([5]), Amoroso N. ([6]), Crucitti P. ([7]), Longo F. ([7]), Monaco A. ([2])([3]), Naciu A.M. ([8]), Palermo A. ([8]), Taffon C. ([5]), Tangaro S. ([2])([9]), Crescenzi A. ([5]), Sodo A. ([4]), Bellotti R. ([2])([3])
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Due to its capability of identifying biochemical changes occurring during oncogenesis, coupled with its non-invasive and label-free nature, Raman Spectroscopy (RS) represents a promising diagnostic tool for thyroid cancer, leading to better management of indeterminate nodules and unnecessary surgery reduction with respect to molecular tests. The key challenge in the diagnostic application of RS is the interpretation of the spectra and extraction of relevant information. In the present contribution, we present an analysis aimed at developing and optimizing machine learning algorithms able to distinguish Raman spectra associated to healthy or benign nodules from those associated with cancer diagnosis. The considered dataset consists of Raman spectra obtained from histological samples, and algorithms are trained on the relative prominence of spectral peaks, identified by a data-driven procedure. The accuracy of the proposed model in classifying tissues as healthy/benign or cancerous exceeds 90%. We use explainable Artificial Intelligence methods to identify the most impactful variables in determining the prediction related to each sample, increasing the interpretability of results.

Caratterizzazione di lieviti per applicazioni enologiche mediante microspettroscopia nel medio infrarosso in riflessione totale attenuata.

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([1]) *Dipartimento di Informatica, Università di Verona, Italia*
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La spettroscopia e la micro-spettroscopia nel medio infrarosso, anche abbinata a tecniche di analisi statistica multivariata come l'analisi per componenti principali, è una tecnica rapida, accurata e sensibile per la caratterizzazione dei sistemi biologici e dei processi metabolici, che permette di ottenere informazioni sulle componenti biochimiche (proteine, lipidi, carboidrati) delle cellule e delle pareti cellulari. In particolare, la tecnica della riflessione totale attenuata può essere applicata direttamente a colture cellulari senza trattamenti invasivi e senza richiedere l'uso di supporti trasparenti all'infrarosso. Di particolare interesse sono gli studi volti alla caratterizzazione e alla selezione di lieviti per la produzione enologica, come dimostrato dai significativi risultati in questo campo ottenuti all'Università di Verona nell'ambito di una collaborazione tra il laboratorio di Spettroscopia e Microspettroscopia nell'Infrarosso e il laboratorio di Microbiologia e Biotecnologia degli Alimenti.

Significant alterations of barley seed samples by electromagnetic stresses.

Nassisi V. ([1])([2]), Alifano P. ([2]), Anglana C. ([3]), Barozzi F. ([3]), Calcagnile M. ([2]), Tredici S.M. ([2]), Di Sansebastiano G.P. ([3])
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Electromagnetic fields were used to stimulate seed germination and to investigate the variables of growth after germination. In this work, different electromagnetic waves were generated by transmission lines to stress barley seeds. The stress was operated by low (100 kHz), very high (10 MHz) and ultra-high (1 GHz) radiofrequency. All samples were exposed to the above radiofrequency for one, two and three days. The geometry of the lines we built was flat and was designed with a height of $h = 1.35$ cm, width of $a = 9$ cm, and length of 10 and 20 cm. The length of the line does not affect the line efficiency, and it allows the processing of multiple samples simultaneously. Two ROHDE & SCHWARZ RF generators were employed: the SM 300 and the SMF 100. The electric and magnetic fields associated to the wave were of 74 V/m and 247 nT, respectively. About 20 seeds for each experiment were employed and as many were kept as control. Plantlets were grown *in vitro* and in open field. Several parameters such as dry weight, root and shoot length were analysed, describing a complex scenario.

Correlazione tra incremento della massa magra corporea e terapia fisica mediante vibrazioni.

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Università di Messina, Dipartimento di Scienze Biomediche, Odontoiatriche e delle Immagini Morfologiche e Funzionali

L'astensione forzata dalle normali attività fisiche causa al paziente la perdita della massa muscolare (sarcopenia) e la possibilità di incremento di osteoporosi. Le due patologie sono infatti spesso correlate tra loro e si incrementano nelle condizioni di riposo forzato. Il paziente, pertanto, viene sottoposto a fisioterapia per riprendere la forza muscolare per espletare le normali attività. Una delle tecniche fisioterapiche è quella strumentale mediante pedane vibranti (WBT) ad oscillazione verticale, orizzontale o basculanti. Le pedane più utilizzate sono quelle ad oscillazione verticale sulle quali esiste una vasta letteratura scientifica a proposito dei risultati terapeutici conseguiti. Il parametro più importante ai fini terapeutici è la frequenza delle oscillazioni che varia dai 20 ai 35 Hz, altro parametro è anche l'ampiezza delle oscillazioni che viene settata sui valori ricavati dalla letteratura scientifica. Gli AA si propongono di verificare tramite impedenziometria l'attinenza tra WBT e l'incremento di massa muscolare in soggetti sottoposti a terapia vibrazionale.

Development of a data-driven personalized model for human glucose homeostasis through a digital web-based application powered by wearable sensors.

Riente A., Bianchetti G., Abeltino A., Serantoni C., De Spirito M., Maulucci G.
Dipartimento di Neuroscienze dell'Università Cattolica del Sacro Cuore di Roma, Istituti Biologici e Fondazione Policlinico Universitario A. Gemelli, Roma

For survival of human beings is essential the homeostasis of glycemia that is influenced by macronutrients in the diet, physical activity, chewing and others. About macronutrients, it is known that the quantity of carbohydrates increases blood sugar. Regard human chewing, it is a complex act involving different structures which simultaneously combines shredding and lubrication of food. An accurate chewing resulted in a lower values of postprandial plasma glucose and concentrations of YY peptide and GLP-1. About physical activity, glucose levels differ based on the duration and the intensity of the exercises. We collect data about glucose levels using wearable device; masticatory habits using "Chewing", an electromyographic device developed in our lab; and dietary, anthropometric, and physical activity data integrated in ArMOnIA, a digital web-based application developed by our lab. Then, accurate models are built to quantify the individual responses of the endocrine systems

in view of projecting a personalized model of metabolism. This approach provides correct clues to empower citizens with scientific knowledge, increasing their self-awareness to pursue a healthy lifestyle.

Making a transition to a healthy lifestyle by assessing resting heart rate determinants.

Serantoni C., Bianchetti G., Riente A., Abeltino A., De Spirito M., Maulucci G.
Department of Neuroscience, Metabolic Intelligence Lab, Università Cattolica del Sacro Cuore e Fondazione Policlinico Universitario "A. Gemelli" IRCCS, Rome, Italy

Resting heart rate (RHR) is gaining importance as an indicator of everyone's health and a predictor of cardiovascular-related diseases. The higher a person's resting heart rate, the greater the risk of premature death. The role of diet on resting heart rate is still not clear and under investigation. Here we present a clustering model to investigate the role of macronutrients intake and metabolism on cardiovascular response. 6 participants (50% males and 50% females, age = 41 ± 11 years) collected Heart Rate data 24/7 and weight (every morning) for about 90 days with Xiaomi® smart bands and balances. They also recorded detailed daily food diaries. A k-means clustering has been performed on RHR. High RHR and low RHR clusters have been isolated. RHR is directly proportional to Heart Rate Standard deviation during sleep. Low RHR is associated with low fats intake and high fibers intake suggesting a protective property of the fibers on cardiovascular health. These results may furnish a key in changing diet habits making a transition from high to low RHR and thus improving cardiovascular health.

Aula F5 - Hildred Blewett **ore 15:10 – 19:30**

Sezione VI

Fisica applicata, acceleratori e beni culturali

Presiede: Palumbo L. (Università di Roma Sapienza)

Relazioni su invito

▲ **Synchrotrons in the Global South. Role of Italy and Europe.**

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Despite the relevance of synchrotron light sources in achieving the United Nations' Sustainable Development Goals, there is only one synchrotron in Latin American (SIRUS in Campinas, Brazil) and currently none in Africa. Given the significance of synchrotron developed research in key areas such as reducing poverty, boosting economic development and fighting climate, there have been several proposals in recent years to work towards building such big science projects in these areas, although in Latin America, this has only taken place at a national level, mainly in Mexico, but with interest in Colombia, Cuba and Puerto Rico, as well. However, there is now strong momentum to establish a second synchrotron in the Greater Caribbean Region, as well as the first one in Africa by proponents of the two geographical spheres partnering in their efforts. This communication presents recent developments and analyzes the necessary political, economic and scientific support required to progress these projects, including potential South-South cooperation with SIRIUS and the Middle East synchrotron, SESAME, as well as North-South cooperation with the potential for Europe and Italy to play a significant role.

▲ **The challenges of beam monitoring from particle therapy to FLASH radiotherapy.**

Vignati A.

Dipartimento di Fisica, Università degli Studi di Torino, Italia e National Institute for Nuclear Physics, INFN, Sezione di Torino, Italia

Beam monitors are radiation detectors used to guide pencil beam scanning deliveries in particle therapy and to online verify radiotherapy treatments. Advanced dose delivery techniques in particle therapy, such as volumetric rescanning, and the advent of FLASH radiotherapy promise to improve treatment outcomes, but require a step forward in beam monitors' technologies. Innovative approaches in beam monitoring will be presented: the ones aiming at fulfilling the outstanding requirements of FLASH irradiations, thus contributing in studying and possibly translating into clinics the FLASH effect; and the ones aiming at online monitoring both primary beams and secondary radiation, thus enabling range and dose verification in particle therapy.

Comunicazioni

● **Design and test of C-band linac prototypes for electron FLASH radiotherapy.**

Giuliano L., Bosco F., Carillo M., Ficcadenti L., Mostacci A., Palumbo L., Migliorati M., Faillace L., Spataro B., Felici G., Di Francesco M.

La Sapienza, Università di Roma

The FLASH Therapy is a revolution in the cancer cure, since it spares healthy tissue from the damage of the ionization radiations without decreasing its effectiveness in the tumor

control. To allow the implementation of the FLASH therapy concept into actual clinical use and treat deep tumors, Very High Electron Energy (VHEE) should be achieved in the range of 50–150 MeV. In the framework of the VHEE project carried out at Sapienza University, in collaboration with INFN, we investigate the main issues in the design of a compact C-band (5.712 GHz) electron linac for FLASH radiotherapy. In this paper we describe the design strategy, the electromagnetic properties and the first prototype of the RF structure to be tested at Sapienza University.

Laboratorio di crio-microscopia elettronica (EYE lab) CNR-ISASI Napoli.

Esposito E., Sanità G., Rendina I.
Institute of Applied Sciences and Intelligent Systems, Naples Cryo Electro Microscopy Laboratory, EYE Lab, National Research Council, Naples, Italy

Questa comunicazione è volta alla presentazione di un nuovo centro di crio-microscopia elettronica del CNR recentemente realizzato presso l'Area di Ricerca di Napoli, una facility aperta che intende fornire alla comunità scientifica gli strumenti per compiere ricerche alla frontiera della conoscenza in biomedicina. Il laboratorio di Cryo-EM offre la possibilità di identificare, visualizzare e caratterizzare macromolecole biologiche da sole e nel loro ambiente cellulare. Il laboratorio Cryo-EM è progettato per combinare in modo efficiente diversi flussi di lavoro per l'analisi di particelle singole (Single Particle Analysis), che fornisce la struttura 3D ad alta risoluzione di proteine e altre macromolecole e la tomografia elettronica (ET), che viene utilizzata per osservare e misurare l'architettura interna di cellule. È inoltre possibile analizzare e caratterizzare nanosistemi sia tramite microscopia TEM che SEM in condizioni Cryo o a temperatura ambiente.

An active plasma chamber design for ECR Ion Sources.

Russo F. ([1]), Castro G. ([1])([1]), Chines F. ([1]), Costanzo G. ([1]), Leonardi O. ([1]), Siliato D. ([1]), Celona L. ([1]), Gammino S. ([1]), Odorici F. ([2]), Malferrari L. ([2]), Guerzoni M. ([2]), Furini M. ([2]), Gessi C. ([2]), Margotti A. ([2]), Michinelli R. ([2])
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An innovative plasma chamber for Electron Cyclotron Resonance Ion Sources has been developed at INFN and will be tested inside the AISHa (Advanced Ion Source for Hadrontherapy) ion source. Its design allows reducing the ion losses induced by the anisotropic diffusion mechanism to improve plasma confinement and increase ion source performances. Indeed, in ECRIS plasmas, electrons diffuse mainly along the magnetic field lines while ions are mainly lost across the magnetic field lines. The inner walls of the plasma chamber are covered by 30 tiles each one polarized with a given positive voltage. The tiles are made of Al-6082 and anodized except for the surface directly facing the plasma. The anodization process makes each tile electrically insulated from the others and from the plasma chamber while preserving the correct operation of the cooling system. The tiles are wrapped by 2 half-cylinders made of Al-6082 acting as shells. Some tiles are equipped with a temperature sensor and machined to allow the wiring of the entire system. In this communication preliminary tests and future perspectives will be discussed.

Numerical study of sub-relativistic co-propagating DLA structures.

Leiva Genre A. ([1]), Mauro G. S. ([1]), Mascali D. ([1]), Torrisi G. ([1]), Bacci A. ([2]), Palmeri R. ([3]), Sorbello G. ([4])
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This communication discusses the potential of the structure longitudinal dimension tapering as a key feature in Dielectric Laser Accelerators (DLA) to achieve on-chip acceleration of particles from tens of keV to MeV energies. A numerical study of structures suitable for sub-relativistic acceleration, based on tapered slot electromagnetic band gap (EBG) waveguides, with an engineered channel/defect modification that allows for a variable phase velocity matched to the increasing velocity of the accelerated particles is presented. The present work highlights the use of co-propagating schemes in DLA structures for higher efficiency and a smaller footprint. The authors propose tapered continuous co-propagating structures that enable wave launching/coupling, beam acceleration, and transverse focusing simultaneously. The main figures of merit, such as the accelerating gradient, total energy gain, and transverse focusing/defocusing forces, are evaluated and used to guide the optimization of the channel/defect modification. The engineered channel/defect modification proposed in this study could pave the way for the development of high-performance sub-relativistic DLA structures.

Design and realization of high-gradient C-band standing wave RF gun.

Cardelli F., Alesini D., Vannozzi A., Liedl A., Giribono A., Di Raddo G., Lauciani S.

INFN-LNF, Istituto Nazionale di Fisica Nucleare

To generate ultra-high brightness electron beams it is highly advantageous to use injectors based on Radio frequency photo-guns with very high cathode peak electric field. The current state of the art is the S-band (3 GHz) that allows to obtain cathode field at the level of 100 MV/m. To overcome the limits of this operating frequency a promising approach is to realize RF guns working at the C-band frequency (5712 MHz). In the context of the European I.FAST project and INFN Commission V, a new C-band RF gun has been designed and realized at the INFN laboratories of Frascati. This RF gun has been fabricated with the brazing-free technology developed at the INFN and already applied to other electron sources. In this communication we present the design, the realization and the first tests performed on this prototype.

Optical emission spectroscopy and microwave reflectometry for magnetized plasmas: Applications to ion sources and fusion machines.

Emma G. ([1]), Agnello R. ([2]), Bezmalinovich M. ([3])([4]), Cavazzana R. ([2]), De Masi G. ([2]), Finocchiaro G. ([1])([5]), Galatà A. ([6]), Mauro G. S. ([1]), Mazzaglia M. ([1]), Mishra B. ([1])([5]), Naselli E. ([1]), Pidatella A. ([1]), Santonocito D. ([1]), Torrisi G. ([1]), Mascali D. ([1])([5])

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Investigation of magnetized plasmas by advanced diagnostics is a relevant topic mainly in the ion sources field for high-performance particles accelerators and in the thermonuclear fusion research for energetic purposes. Here, two different diagnostics techniques will be presented: high-resolution OES (Optical Emission Spectroscopy) and MR (Microwave Reflectometry) which can provide complementary information concerning plasma properties. OES is employed in ion sources to estimate cold electron plasma density and temperature. Results of

OES measurements carried out at INFN-LNS, in the framework of the PANDORA (Plasma for Astrophysics Nuclear Decay Observation and Radiation for Archaeometry) project to study plasma opacity and heavy elements nucleosynthesis abundances, will be given. MR instead finds extensive use in tokamak plasmas to perform 1D electron density profile reconstruction. We will present an on-going R&D of the waveguide's system to perform reliable reflectometry measurements which will be relevant for the DTT (Divertor Tokamak Test) project. An overview of the perspectives and challenges of the two diagnostics systems, with an eye to future results, will be given.

Beam loss monitors characterization for SPES proton beam line.
Allegrini M.L., Benini D., de Ruvo P.L, Maggiore M., Pranovi L., Prete G.
INFN, Laboratori Nazionali di Legnaro, Legnaro, Italia
Beam Loss Monitors will be installed along the primary SPES beam line to detect proton beam losses in the cyclotron area. They will be connected to the cyclotron Machine Protection System (MPS). This communication shows the work of characterization of such devices. Preliminarily, the characteristics of models used in other facilities with features similar to SPES (Proton beam energy = 40–70 MeV and current = 200–500 A) were analyzed. Instrumentation Technologies-Libera, a company that makes potentially suitable devices for the SPES facility, was contacted as a possible supplier. They offer a system designed for beam loss measurements based on scintillators integrated on Photomultiplier, flash ADC and data acquisition. The gain is controlled by dc voltage managed by the system. Detectors and electronics have been tested in two steps: 1) irradiation with gamma and neutrons static sources; 2) irradiation with the CN accelerator beam (zero-degree line). From the tests, the detectors resulted very reactive to gamma and neutron radiation, so they could be suitable to be implemented at SPES as beam loss monitors.

Characterisation of 6MBGEM: A boron-coated GEM-based neutron detector optimised for transmission measurements at spallation sources.
Cancelli S., Caruggi F., Muraro A., Putignano O., Perelli Cippo E., Celora A., Gorini G., Grosso G., Tardocchi M., Croci G.
Università degli Studi Milano-Bicocca
Experiments at future spallation sources constantly require the development of new detectors capable to sustain the high neutron flux without event losses and also with high detection efficiency in order to perform measurements in a short time. For this reason, we have developed a new gas detector based on the Gas Electron Multiplier (GEM) technology with the presence of the innovative boron GEM (BGEM) foils (GEM foils covered on both sides with a boron layer to convert neutrons into detectable charged particles). Stacking several BGEM foils, the presence of boron inside the detector increases without limiting the movement of the secondary charged particles, bringing, as a consequence, an increase of the detection efficiency. This communication presents the results of the detector characterization at the ISIS Neutron and Muon Source (UK) at the beamline VESUVIO, where the detector has been tested with thermal and epithermal neutrons. The detector has been studied with the use of different samples, such as vanadium, and the thermal and epithermal neutron flux has been determined and compared with the other GEM detector already located on the beamline.

Sub-THz waveguide spectroscopy for the electromagnetic characterization of different Non-Evaporable Getter coatings.
Passarelli A. ([1]), Mazaheri Z. ([2]), Himmerlich M. ([3]), Costa Pinto P. ([3]), Vollenberg W. ([3]), Krkotic P. ([3]), Calatroni S. ([3]), Andreone A. ([1])([2]), Masullo

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Non-Evaporable Getter (NEG) coatings are currently used in vacuum chambers of particle accelerators for their effective pumping ability and for suppressing electron cloud instabilities. At the same time, their presence may affect the beam coupling impedance and, therefore, the machine performance. To study this behavior, the electromagnetic characterisation (EMC) is crucial. In particular, in the next generation of particle accelerators very short bunches are required, rendering more and more important to assess the coating material response up to hundreds of GHz. This paper describes the EMC of three different NEG coatings, (CERN standard, densified film using HiPIMS and porous, coated at high pressure), resorting to a time domain method based on THz waveguide spectroscopy.

Il silicio amorfo idrogenato come rivelatore di radiazione ionizzante.

Gianfelici B. per la HASPIDE Collaboration
Università degli Studi di Camerino e INFN, Sezione di Perugia
La richiesta di rivelatori in grado di offrire una misura precisa di flussi di radiazioni ionizzanti di vario genere con un elevato range dinamico e una grande resistenza al danneggiamento da radiazioni è in costante aumento. Il silicio amorfo idrogenato (a-Si:H) costituisce un valido candidato a causa della sua elevatissima resistenza alle radiazioni. Inoltre, può essere depositato in film sottili su molti tipi di substrati. È un materiale ampiamente utilizzato per esempio per pannelli fotovoltaici e per flat-panel per radiografie, e quindi esiste già una tecnologia di deposizione che consente la costruzione a basso costo, su grandi superfici e con qualità industriale, che implica una elevata uniformità costruttiva. Il progetto di ricerca HASPIDE mira allo sviluppo e all'utilizzo di strati sottili di a-Si:H (1–10 μm) come rivelatori di fasci di radiazione sia in campo clinico che non clinico, per la rivelazione nello spazio di particelle cariche e neutre e anche per la misura di neutroni previa deposizione di ^{10}B. Verranno presentati i risultati preliminari della caratterizzazione di alcuni prototipi soprattutto per quello che riguarda rumore, linearità di risposta e sensitività.

Optical fiber meta-tips based on holey metasurface for wavefront manipulation.

Principe M. ([1]), Vaiano P. ([1]), Berruti G. ([1]), Micco A. ([2]), Consales M. ([1]), Cusano A. ([1])
([1]) *Dipartimento di Ingegneria, Università del Sannio*
([2]) *Centro Regionale Information Communication Technology*
Optical fibers are of great technological importance due to their unique features such as flexible handling, strong light confinement, and efficient light transportation over large distances, representing a key element in a multitude of applications in modern optics, including fiber communications, analog computing, optical trapping, sensing, and imaging. The integration of optical metasurfaces (MSs) on the tip of an optical fiber is able to enormously expand the fiber functionalities, by endowing a simple optical fiber with extraordinary capabilities of light manipulation. Furthermore, properly designed MSs are able to replace traditional bulky optical components, with the great advantage of reducing the size of the devices. In 2017 we realized the first optical fiber meta-tip (OFMT) for wavefront modulation, based on plasmonic antennas which were able to span the entire 2π phase range on the cross-polarized transmission coefficient, suffering however low efficiency. Here we go a step ahead and realize OFMTs based on aperture antennas in a gold layer, spanning a partial phase range, which are able to steer and focus the outcoming light beam with higher efficiency.

Aula F2 - Ginestra Giovene Amaldi **ore 15:10 – 19:30**

Sezione VII
Didattica e storia della fisica
Presiede: Michelini M. (Università di Udine)

Relazioni su invito

▲ **Riflessioni sull'insegnamento della fisica dal progetto FEDORA e dal GreenComp.**
Levrini O.
Dipartimento di Fisica e Astronomia "A. Righi", Università di Bologna, Bologna, Italia
Nell'intervento saranno presentati alcuni risultati ottenuti nel progetto FEDORA (www.fedora-project.eu) al fine di rispondere a queste domande: Come possiamo aiutare studenti e studentesse di scuola secondaria a trovare, nello studio della fisica, risorse necessarie per navigare in una società complessa, fragile e in rapido cambiamento? Come possiamo rigenerare il valore delle discipline in un'era in cui sono sempre più richieste competenze inter-multi-trans-disciplinari? Di quali nuovi linguaggi può arricchirsi l'insegnamento della fisica per mettersi in sintonia con i tempi attuali? Nel presentare i risultati, si argomenterà come, attraverso la sua ricerca, FEDORA abbia cercato di promuovere una cultura dell'innovazione e della creatività nell'educazione scientifica, promuovendo, al tempo stesso, sostenibilità, diversità e inclusione. Si mostrerà anche come il progetto abbia interpretato e inglobato i principi di base del GreenComp, il recente quadro di competenze europeo per la sostenibilità.

▲ **Metodi quantitativi nella ricerca in didattica della fisica: analisi critica della letteratura e nuove prospettive.**
Testa I.
Dipartimeto di Fisica "E. Pancini", Università di Napoli Federico II, Napoli, Italia
A partire dal novembre 2022, *Physical Review Physics Education Research* ha annunciato l'istituzione di un comitato per valutare la qualità dei metodi statistici utilizzati negli articoli sottomessi alla rivista. L'istituzione di questo comitato riflette il numero crescente di ricerche che sfruttano tecniche come le equazioni strutturali, la regressione lineare e l'analisi di Rasch. Sebbene lo scopo di questo comitato sia quello di alleviare i revisori dall'approfondire i dettagli tecnici degli articoli, esso segnala anche la necessità sempre più stringente per i ricercatori di supportare le proprie proposte attraverso metodi quantitativi adeguati. Nella prima parte, esaminerò le principali tecniche statistiche utilizzate nella ricerca in didattica della fisica spiegando perché è necessaria una interazione con le comunità degli statistici e degli psicologi dell'educazione. La mancanza di tale integrazione è il principale impedimento a trovare consenso sui risultati ottenuti anche all'interno della stessa comunità dei didattici della fisica. Nella seconda parte, si proporranno possibili nuovi problemi di ricerca basandosi sulle possibilità offerte da metodi statistici avanzati.

▲ **Pensiero critico e strutturazione concettuale in termodinamica: uno studio sulle orme di Laurence Viennot.**
Malgieri M., Pozzi E.
Dipartimento di Fisica, Università di Pavia, Pavia, Italia
In questa relazione sarà presentato uno studio sul pensiero critico degli insegnanti messi di fronte ad una contraddizione tra diversi libri di testo riguardante la definizione di rendimento

delle macchine termiche. Lo studio si compone di due parti: la prima consiste di interviste semistrutturate agli insegnanti, ai quali viene proposto di commentare due diversi problemi risolti con soluzioni tra loro contraddittorie. La seconda riguarda l'analisi del contenuto dei libri di testo, di scuola secondaria e universitari, sull'argomento in oggetto. Per entrambe le componenti dello studio vengono adottati i paradigmi interpretativi originati dal decennale lavoro su questi temi di Laurence Viennot, recentemente scomparsa. Nelle conclusioni della relazione verranno ricavati dai risultati dello studio alcuni suggerimenti per la formazione iniziale degli insegnanti.

Comunicazioni

Informal and non-formal learning of physics: methods and measures to develop an integrated model of learning and teaching of physics.

Tuveri M. ([1])([2]), Fadda D. ([3]), Steri A. ([2]), Stefanizzi R. ([1])([2]), Vivanet G. ([3]), Bonivento W. ([2]), Carbonaro C. M. ([1]), Fanti V. ([1])([2])
([1]) *Dipartimento di Fisica, Università di Cagliari, Cittadella Universitaria di Monserrato, Monserrato, CA, Italy*
([2]) *INFN, Sezione di Cagliari, Cittadella Universitaria di Monserrato, Monserrato, CA, Italy*
([3]) *Dipartimento di Filosofia, Psicologia, Pedagogia, Università di Cagliari, Cagliari, Italy*

Informal learning contexts have always represented a great teaching opportunity and their role is increasingly recognized also at the institutional level. We discuss its features and potential role in facilitating science and physics instruction, integrating pedagogical theory and education research. We illustrate how to build a suitable pedagogy to use the good practices of informal learning concerning the fostering of motivation, curiosity, and interest towards physics, as well as to spread and bring physics in high schools and in the public to construct an integrated teaching pedagogy that mixes formal, non-formal and informal student-centered learning. We will also show the potentiality of this approach in providing alternative (supplementary) materials and tools for formal teaching and learning of physics in high schools. Moreover, we also focus on the qualitative and quantitative measure of the efficacy of informal learning by using suitably research questionnaires. Results in some explicit examples developed by the Educational Division of the Physics Department at the University of Cagliari are shown.

Ricostruzione didattica della Seconda Rivoluzione Quantistica da una prospettiva culturale: sviluppo di un percorso per studenti di scuola secondaria superiore.

Satanassi S., Ercolessi E., Levrini O.
Dipartimento di Fisica e Astronomia, Università di Bologna, Bologna, Italia

Il Premio Nobel 2022 è stato attribuito ad Aspect, Clauser e Zeilinger per i loro esperimenti sui fotoni entangled, dimostrando la violazione delle disuguaglianze di Bell e aprendo la strada alla scienza dell'informazione quantistica. C'è un parallelismo tra Prima e Seconda Rivoluzione Quantistica: entrambe si basano su due misteri della fisica quantistica (la prima il principio di complementarità, la seconda l'entanglement), entrambe nascono nel mondo degli "gedankenexperiment" (il dibattito Bohr-Einstein la prima, il dibattito Bohr-Einstein sul paradosso EPR la seconda) ed entrambe sono state messe alla prova dei fatti reificando quello che viveva "nel mondo dei pensieri" nel "mondo reale", progettando un esperimento. Partendo da questo parallelismo, abbiamo sviluppato un percorso per studenti di scuola secondaria che traccia un percorso tra la Prima e la Seconda Rivoluzione Quantistica sino ad arrivare alla computazione classica e quantistica e alle principali applicazioni che già

oggi sono state sviluppate e implementate: il protocollo di crittografia quantistica e del teletrasporto.

Il cambiamento climatico: rappresentazioni grafiche e mentali dell'effetto serra.

Fiorello C. ([1]), Di Mauro M. ([1]), Malgieri M. ([2]), Rosi T. ([1]), Toffaletti S. ([1]), Onorato P. ([1]), Oss S. ([1])
([1]) *Dipartimento di Fisica, Università di Trento, Povo, TN, Italia*
([2]) *Dipartimento di Fisica, Università di Pavia, Pavia, Italia*

Il cambiamento climatico è una delle sfide più importanti per l'umanità, ma la sua complessità e natura interdisciplinare richiedono una lettura, comprensione e interpretazione approfondita di diverse discipline. Gli studenti e le studentesse devono avere una visione concettuale ampia dell'argomento per sviluppare un pensiero scientifico critico. Questa ricerca si concentra sulle potenziali misconcezioni e incoerenze nella comprensione dell'effetto serra. L'analisi dei disegni e degli schemi prodotti dagli studenti e studentesse può svolgere un ruolo importante nel determinare se si è giunti a un modello mentale coerente di questo fenomeno. Abbiamo, pertanto, esaminato i disegni prodotti a diversi livelli di istruzione prima di esporre i partecipanti a una sequenza di insegnamento-apprendimento dedicata all'argomento. Si evidenzia come i disegni e gli schemi possano essere influenzati da vari fattori, tra cui immagini eventualmente imprecise presenti nei libri di testo o altre fonti, inclusi siti web.

Cambiamenti climatici: le basi fisiche di fenomeni radiativi per lo studio dell'effetto serra.

Toffaletti S. ([1]), Di Mauro M. ([1]), Fiorello C. ([1]), Malgieri M. ([2]), Rosi T. ([1]), Tufino E. ([1]), Onorato P. ([1]), Oss S. ([1])
([1]) *Dipartimento di Fisica, Università di Trento, Povo, TN, Italia*
([2]) *Dipartimento di Fisica, Università di Pavia, Pavia, Italia*

L'insegnamento efficace delle basi fisiche dell'effetto serra è un elemento essenziale per comprendere il ruolo della società nella modifica degli equilibri radiativi che stanno conducendo ai cambiamenti climatici di stringente attualità. I risultati delle recenti ricerche nella didattica della fisica in questo campo mostrano che due concetti chiave per la sua comprensione sono appresi in modo ancora incompleto da parte di studenti e studentesse: si tratta dell'emissione termica dei corpi e dell'interazione della radiazione elettromagnetica a varie frequenze con differenti materiali. Con questo lavoro presentiamo alcuni esperimenti volti a favorire l'apprendimento di questi concetti e il loro inserimento all'interno di una sequenza didattica di insegnamento-apprendimento preesistente, incentrata sulle basi fisiche dell'effetto serra. Verranno illustrati e commentati i risultati di questa sperimentazione anche in confronto con precedenti proposte.

Un percorso PCTO tra clima ed energia.

Zatti L. ([1]), Aimè C. ([2])([3]), Armanetti A. ([2]), Braghieri J. ([2]), Aurelio D. ([4]), Budassi E. ([2])([3]), Maragnano D. ([2]), Montagna P. ([2])([3]), Pirola M. ([2])([3]), Restelli S. ([2]), Santostasi D. ([5]), Trupia D. ([6]), Venturini S. ([2])([3]), Verdi S. ([2])
([1]) *Dipartimento di Ingegneria Industriale e dell'Informazione, Università di Pavia, Pavia, Italia*
([2]) *Dipartimento di Fisica, Università di Pavia, Pavia, Italia*
([3]) *INFN Sezione di Pavia, Pavia, Italia*
([4]) *IIS "L. G. Faravelli", Stradella, PV, Italia*
([5]) *Liceo Ginnasio Statale "Benedetto Cairoli", Vigevano, PV, Italia*

([6]) *Istituto Magistrale Statale "Adelaide Cairoli", Pavia, Italia e ITAS "Carlo Gallini", Voghera, PV, Italia*

Si presenta un percorso PCTO proposto dal gruppo Physics4Teenagers dell'Università di Pavia a una classe quarta del Liceo Scientifico Taramelli di Pavia. L'obiettivo è stato abituare gli studenti a sviluppare un senso critico e a formarsi opinioni solide su questioni di attualità e impatto sociale (cambiamenti climatici, questione energetica, sostenibilità ambientale), fondate su dati sperimentali e metodo scientifico e non sulla base di ideologie e posizioni politiche. Partendo da un esame dei recenti dati sperimentali sui cambiamenti climatici e sulle emissioni di CO_2 (anche con una dimostrazione teorico-sperimentale del ruolo dell'effetto serra), si è poi affrontata in dettaglio la questione dell'energia, con un esame delle fonti primarie, dell'impatto ambientale e dei costi di produzione. Si sono presentate in dettaglio le energie rinnovabili, e si è poi posta particolare enfasi alla questione dell'energia nucleare, spiegandone gli aspetti fisici e le implicazioni sociali ed economiche. Gli studenti sono stati chiamati a discutere il tema "Nucleare sì o no?" secondo le regole del modello World School Debate. Si discute l'esito del dibattito come metodo di valutazione del PCTO.

Particle Escape Room: un test didattico.

Armanetti A. ([1]), Aimè C. ([1])([2]), Braghieri J. ([1]), Aurelio D. ([3]), Budassi E. ([1])([2]), Maragnano D. ([1]), Montagna P. ([1])([2]), Pirola M. ([1])([2]), Restelli S. ([1]), Santostasi D. ([4]), Trupia D. ([5]), Venturini S. ([1])([2]), Verdi S. ([1]), Zatti L. ([6])
([1]) *Dipartimento di Fisica, Università di Pavia, Pavia Italia*
([2]) *INFN Sezione di Pavia, Pavia, Italia*
([3]) *IIS "L. G. Faravelli", Stradella, PV, Italia*
([4]) *Liceo Ginnasio Statale "Benedetto Cairoli", Vigevano, PV, Italia*
([5]) *Istituto Magistrale Statale "Adelaide Cairoli", Pavia, Italia e ITAS "Carlo Gallini", Voghera, PV, Italia*
([6]) *Dipartimento di Ingegneria Industriale e dell'Informazione, Università di Pavia, Pavia, Italia*

Nell'ambito del Progetto MUR Physics4Teenagers: il contagio della fisica, il gruppo Physics4Teenagers del Dipartimento di Fisica dell'Università di Pavia ha allestito e presentato a diverse scuole secondarie superiori l'escape room "PER me si va ne la fisica recente: Particle Escape Room". In occasione di due presentazioni a diverse classi (Liceo Bachelet di Abbiategrasso a febbraio 2023, Liceo Galilei-Tiziano di Belluno a marzo 2023), è stato proposto agli studenti un test didattico di fisica nucleare e subnucleare da svolgersi a sorpresa appena prima e appena dopo l'esperienza. Lo scopo era chiaramente di confrontare la (non) preparazione iniziale, spesso anche distorta da modelli mentali e concezioni comuni —su argomenti praticamente non ancora svolti nel programma liceale— con le nuove competenze acquisite attraverso la partecipazione all'Escape Room. Si discutono i risultati di tali test ricavandone osservazioni utili per la didattica della fisica nucleare e subnucleare.

Problema fisico della computazione: un percorso di costruzione della computazione classica per studenti del primo anno di scuola secondaria di secondo grado.

Sutrini C. ([1]), Malgieri M. ([1]), Zuccarini G. ([1]), Ceruti M. C. ([2]), Orelli C. ([2]), Macchiavello C. ([1])
([1]) *Dipartimento di Fisica, Università di Pavia, Pavia, Italia*
([2]) *Liceo Volta, Castel San Giovanni, PC, Italia*

Negli ultimi anni si sono sviluppati percorsi didattici per studenti dell'ultimo anno di scuola secondaria di secondo grado relativi alla teoria quantistica della computazione. Tuttavia l'area di ricerca in didattica dell'Università di Pavia ha ritenuto fin dall'inizio necessaria una

progettazione fin dal primo anno per poter introdurre questi temi nel curriculum. In questo senso era auspicabile la realizzazione di un percorso multidisciplinare che legasse fisica, logica e informatica e che gettasse le basi per i successivi sviluppi. La costruzione di un computer ad acqua fa da sfondo alla possibilità per gli studenti di costruire mappe di senso tra la logica matematica e la fisica classica e permette fin da subito di definire un linguaggio teorico appropriato. Presentiamo il percorso progettato da due insegnanti del Liceo Volta di Castel San Giovanni (PC), i materiali originali costruiti e i risultati della sperimentazione effettuata in una prima liceo scientifico. Discutiamo infine i possibili positivi riflessi per gli argomenti degli anni successivi.

La mia esperienza come tutor degli studenti junior che hanno animato la mostra "Dire l'indicibile" all'Università Roma Tre.

Di Blasi M. ([1]), Barbieri M. ([2]), Gianani I. ([2]), Postiglione A. ([3]), De Angelis I. ([1])([4])
([1]) *Dipartimento di Matematica e Fisica, Università degli Studi Roma Tre, Roma, Italia*
([2]) *Dipartimento di Scienze, Università degli Studi Roma Tre, Roma, Italia*
([3]) *INFN, Laboratori Nazionali di Frascati, Frascati, RM, Italia*
([4]) *INFN, Sezione di Roma Tre, Roma, Italia*

In questo intervento presenterò la mia esperienza e il mio contributo da studente di fisica alla realizzazione della mostra "Dire l'indicibile" che si è tenuta presso l'Università degli Studi Roma Tre in occasione delle Italian Quantum Weeks. Grazie all'esperienza maturata lo scorso anno, quando ho animato la mostra insieme al team di ricercatori, quest'anno ho potuto formare e fornire supporto ad altri studenti di fisica, che insieme a me hanno guidato parte delle visite. Per farlo, ho usato diversi materiali, tra cui un video dell'intera visita svolta dai ricercatori che io stesso avevo realizzato nella scorsa edizione.

Misure e dati scientifici: esperienze didattiche proposte in classe con un'apertura alla citizen science.

Dodero G. ([1]), Telesio F. ([2]), Grosso D. ([2])
([1]) *Liceo "M. L. King", Genova, Italia*
([2]) *Dipartimento di Fisica, Università di Genova, Genova, Italia*

In questo intervento evidenzieremo i frutti più significativi di esperienze sia di formazione dei docenti che di didattica nella scuola secondaria, focalizzate sul concetto di misura e trattazione di dati sperimentali. La misura di quantità rilevanti, come l'accelerazione di gravità, di rapporti fondamentali, come π, e di costanti fondamentali, quali la costante di Planck, possono essere realizzate nella scuola secondaria, anche in condizioni di laboratorio poco attrezzato, e mettere in luce aspetti quali la necessità di misure ripetute, la presenza di intervalli di incertezza ineliminabili e le possibili cause di errore sistematico. Inoltre, di fronte a fenomeni naturali, ad esempio le eclissi di luna, si può superare un approccio meramente osservativo proponendo una quantificazione dei dati, anche partendo da semplici immagini acquisite con dispositivi mobili, in un'ottica di apertura verso la citizen science.

Promuovere la didattica laboratoriale nelle scuole: un esempio di collaborazione tra scuola e università dal progetto LSOSA.

De Angelis I. ([1])([2]), Mobilio S. ([3]), Meneghini C. ([3]), Brancaccio A. ([4]), Conte A. ([5]), Mancinelli C. ([5]), Borgi E. ([5]), De Paolis P. ([6]), Cifelli F. ([3]), Rampioni G. ([3])
([1]) *Dipartimento di Matematica e Fisica, Università degli Studi Roma Tre, Roma, Italia*
([2]) *INFN, Sezione di Roma Tre, Roma, Italia*
([3]) *Dipartimento di Scienze, Università degli Studi Roma Tre, Roma, Italia*

([4]) *Ministero dell'Istruzione e del Merito, Roma, Italia*
([5]) *Accademia delle Scienze di Torino, Torino, Italia*
([6]) *Istituto Istruzione Superiore "Guglielmo Marconi", Civitavecchia, RM, Italia*
Per promuovere nelle scuole la pratica laboratoriale è fondamentale supportare gli insegnanti nella progettazione e nello svolgimento di attività sperimentali. Per questo, nell'ambito del progetto LSOSAlab è stato realizzato e pubblicato un repository di esperienze laboratoriali pensate per la scuola secondaria di secondo grado, ciascuna corredata da una scheda dettagliata di svolgimento in classe dell'esperimento, inclusa l'eventuale raccolta e analisi dei dati. Le esperienze hanno inizialmente preso spunto dall'attività dei Laboratori Itineranti Regionali, che ha visto la presenza dei docenti del Dipartimento di Scienze dell'Università Roma Tre nelle scuole di 20 regioni italiane, ai quali si sono poi aggiunte attività svolte abitualmente in classe presentate da docenti di tutta Italia. I 234 esperimenti risultanti, pubblicati con un processo di revisione analogo a quello degli articoli scientifici, sono oggi raccolti anche nel volume "Fare laboratorio. Guida alla didattica esperienziale". In questa comunicazione verrà descritto il lavoro svolto con le scuole secondarie di secondo grado e le fasi preliminari che si stanno attuando con quelle di primo grado.

Theoretical limits of virtual reality.

Sisini F.
Tekamed srl
In recent years, virtual reality (VR) has undergone significant development, evolving from the first video games created in the '60s to the immersive systems we have today. This technological advancement has led to an intriguing question: Can we deceive the mind to the extent that we cannot distinguish between real and simulated reality? Alongside this inquiry, another intriguing question arises: Can we simulate a non-reality that operates outside of physical laws? To answer these questions, we provided a definition of reality simulation and established theoretical limits on the possibilities of VR. To do so, we must consider the computer as a physical system described by a certain number of degrees of freedom and the VR user as an observer who can interact or observe the computer's degrees of freedom. This perspective allows us to address the issue formally and circumvent philosophical dead ends. The answer to the first question is that theoretically, we can deceive the mind to the extent that we cannot distinguish between real and simulated reality. Additionally, we can simulate a non-real or magical world.

From the development to the final applications of Nuclear Educational kits: to intrigue and train young minds.

Mattone C. ([1]), Alberi M. ([2]), Chiarelli E. ([2]), Garosi P. ([1]), Raptis K. ([2]), Strati V. ([2])
([1]) *CAEN S.p.A., Viareggio, LU, Italia*
([2]) *Dipartimento di Fisica e Scienze della Terra, Università di Ferrara e INFN, Sezione di Ferrara, Ferrara, Italia*
Students can become increasingly familiar with natural radioactivity thanks to a series of educational kits developed by CAEN S.p.A. for Nuclear and Modern Physics experiments. These educational solutions are based on state-of-the-art technologies, instruments, and methods. In the last year, together with some university research groups, a portable detection backpack with an NaI scintillator has been used to train young students in the measurement of environmental radiation. Groups of students of different ages attended theoretical lessons and seminars. Step-by-step instructions were given to guide even very young students towards the final measurement and combine theoretical background, hands-on setup operations, and data analysis. High school teachers of Chemistry, Science, Mathematics and Physics were

involved to guide their students towards the analysis and comprehension of the critical synthesis of the multidisciplinary results. This work describes the instrumentation and the training routes supplied to the students. Moreover, students' feedback was collected via verification tests offering the opportunity to improve the kit and reach an optimum knowledge transfer.

Aula F1 - Augusta Manfredini **ore 09:00 – 13:30**

Sezione I
Fisica nucleare e subnucleare
Presiedono: Malvezzi S. (INFN, Sezione di Milano Bicocca)
De Curtis S. (GGI)

Relazioni su invito

▲ **New results from lattice gauge theory.**
Sanfilippo F.
INFN, Sezione di Roma Tre
Over the last years, lattice gauge simulations of 1uantum chromodynamics has emerged as a powerful tool to investigate the properties of the strong interactions within the framework of Standard Model, achieving subpercent accuracy on a few dedicated observables of great phenomenological interest. In this communication I will review the recent progress achieved, and describe a few selected results in the field of flavor physics, highlighting the future direction of active research.

▲ **Risultati recenti dell'esperimento BESIII.**
Garzia I.
Università degli Studi di Ferrara e INFN, Sezione di Ferrara
Lo spettrometro Beijing Spectrometer III (BESIII) opera presso il collisionatore simmetrico a fasci e^+e^- BEPCII nel regime energetico compreso tra 2 e 4.95 GeV. A partire dal 2009, l'esperimento ha raccolto il più grande campione di dati al mondo nella regione di energia del leptone tau e del charm, rendendo possibile effettuare innumerevoli analisi di spettroscopia adronica sia nel settore dei quark leggeri sia nel settore del charm, oltre a numerosi studi sui decadimenti dei mesoni charmati e studi delle proprietà di adroni leggeri e charmati. In questa comunicazione saranno discussi i risultati più significativi effettuati dalla Collaborazione BESIII nel settore della spettroscopia adronica leggera e del charmonio, nonché le più recenti analisi sull'osservazione di nuovi stati esotici. Inoltre, saranno presentati gli ultimi studi effettuati sugli stati XYZ utilizzando i nuovi dati raccolti fino ad un'energia nel centro di massa di 4.95 GeV.

Comunicazioni

● **Tecniche avanzate di Machine Learning per la ricostruzione dell'energia del leptone tau con l'esperimento CMS.**
Camagni V.
Università di Milano Bicocca e INFN, Sezione di Milano Bicocca
Al giorno d'oggi le tecniche di Machine Learning sono uno strumento fondamentale per l'analisi e la ricostruzione degli oggetti negli esperimenti ad alta energia. Finora, in CMS, tali tecniche sono state brillantemente applicate per l'identificazione di leptoni e jet. Proponiamo una nuova tecnica per la ricostruzione dell'energia del leptone tau, basata su algoritmi di intelligenza artificiale. Questi algoritmi, partendo da tutti i prodotti visibili ricostruiti del decadimento tau e da tutte le altre particelle nell'evento, stimano la vera energia dei neutrini provenienti dai decadimenti tau. Ciò consente una migliore stima dell'energia e della

quantità di moto del tau prima del suo decadimento rispetto all'algoritmo più comunemente utilizzato in CMS (SVFIT), che è, inoltre, estremamente dispendioso in termini di CPU. Queste tecniche sono state sviluppate nel contesto dell'analisi $hh \to bb\tau\tau$ e questo processo, insieme ai principali fondi, viene utilizzato come benchmark per misurare le prestazioni dei nuovi algoritmi.

Data/Monte Carlo comparison framework for the ATLAS flavour tagger input variables.

Brianti G.
Università degli Studi di Trento e TIFPA

The ATLAS Flavour-Tagging Algorithms sub-group (FTAG) is devoted to developing advanced jet tagging methods using state-of-the-art deep learning models. Among them, Graph Neural Networks (GNNs) are emerging as a promising approach due to their ability to exploit the well-structured anatomy of collision events. Recently, a new GNN-based tagger has been introduced for flavour tagging in ATLAS, which improves upon previous taggers by incorporating new input variables and achieving better performance. To ensure that the Monte Carlo (MC) datasets, on which the network is trained, agree with the Data it is necessary to quantify the Data/MC differences in the input variables. A new framework that allows the user to obtain quick Data/MC checks for the jet variables has been developed. The workflow starts from the event selection to the production of the Data/MC plots with the PUMA functionalities for a wide range of variables of interest. In this communication, I will present the framework's main features along with the results obtained.

Performance studies of RPC detectors operated with eco-friendly gas mixtures.

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The project, made in collaboration with the CERN EP-DT Gas Team, consists in the study of the performance of RPC (Resistive Plate Chamber) detectors operated with eco-friendly gas mixtures. These detectors find a great use at the CERN LHC experiment as muon trigger, due to their excellent time resolution. Currently they are operated with a greenhouse gas (GHG) mixture, containing $C_2H_2F_4$ and SF_6, that have a high Global Warming Potential (GWP) and thus they are subject to European regulations for the reduction on the use of GHG. In this communication RPCs were tested at the CERN Gamma Irradiation Facility (GIF++), that provides a high-energy muon beam combined with an intense gamma source to simulate the background radiation expected at the High Luminosity LHC Phase. The eco-friendly gas mixtures selected for the studies contain alternative gases with a low GWP such as CO_2 and the new Hydro-Fluoro-Olefin gases. The data obtained were analyzed and performances were compared with the RPC gas mixture, nowadays in use at ATLAS and CMS experiments. The gas mixture with the best trade-off between GWP and good detector performance was selected. Now several RPCs are under aging tests at GIF++.

Construction and tests of the RPC-BIL read-out strip panels pre-series for the Phase-II ATLAS detector upgrade at INFN-Gruppo Collegato di Cosenza.

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The RPC-BI project for the Phase-II ATLAS detector upgrade foresees the Muon Spectrometer improvement in the barrel region in terms of trigger acceptance, muon selection and muon momentum resolution by means of the installation of a further layer of new generation RPC trigger chambers (96 RPC-BIS + 176 RPC-BIL triplets). The INFN-Gruppo Collegato di Cosenza is responsible for the construction and validation of 350/700 RPC-BIL read-out strip panels. These panels will be produced by gluing a 3 mm thick aramid paper honeycomb foil between two single-sided copper-coated FR4 plates. One of the two plates is photo-incised to form the reading strips. The serial production of these panels will start in July 2023 and will be preceded by the construction and testing of the pre-series panels, which will serve to demonstrate the ability of the Cosenza site to produce the panels with the requirements defined in the final detector design. In this communication we present the construction procedures and the QA/QC tests and respective results obtained from the pre-series readout panels.

Measurement of the breackdown voltage in ATLAS NSW micromegas electrodes with and without the mesh-anode spacers, for pure Ar, Ar:CO_2 and Ar:CO_2-IsoC_4H_{10} gas mixtures.

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The breakdown voltage between the stainless-steel mesh and the resistive electrode used as anode in the ATLAS NSW micromegas chambers, was measured with and without the spacers, for two very different values of the anode resistivity and 3 different gases. The presence of spacers has the effect of reducing the breakdown voltage. In this communication we try to provide a qualitative interpretation of this phenomenon and of the influence that the gaseous mixture used and the resistivity of the anode have on the breakdown voltage value.

Trigger and Tau-ID improvements for the di-Higgs search in the bbtautau final state with Run 3 data at the ATLAS experiment.

Fiacco D.
Università di Roma La Sapienza e INFN, Sezione di Roma 1

The Large Hadron Collider (LHC) has the potential to estimate the Higgs-boson self-coupling by examining di-Higgs events. The full Run 2 data-taking period reached an integrated luminosity of 140 fb^{-1}, that is expected to at least double by the end of the ongoing Run 3 of the LHC. However, due to the small di-Higgs production cross-section, it is anticipated that higher data statistics will be necessary to detect this process. As a part of this effort, we present the results of an ongoing study investigating new triggers to be implemented in ATLAS during the Run 3 data taking for the di-Higgs search in the bbtautau final state. The Tau Identification (Tau-ID) is a crucial aspect of identifying hadronically decaying tau-leptons in di-Higgs events in the bbtautau final state. A novel Tau-ID algorithm will be presented that surpasses the existing Recurrent Neural Network (RNN)-based approach, and will be compared to other algorithms used in ATLAS. The proposed algorithm is based on a Transformer architecture, which captures the complex correlations among the constituent particles of the tau jets, leading to a new state-of-the-art Tau-ID in ATLAS.

Measurement of the high-mass Drell-Yan process with tau leptons and search for leptoquarks coupling to third-generation fermions at $\sqrt{s} = 13$ TeV with the ATLAS detector.

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An analysis of the LHC Run 2 pp collision dataset with at least two charged leptons, one of which is a τ lepton, collected by the ATLAS experiment is presented. This analysis focuses on the events in which the visible invariant mass of the two leptons is well above the Z boson resonance. Two primary results are reported: a search for new heavy particles coupling to τ leptons and b quarks, and a measurement of a fiducial differential cross-section, unfolded to the stable particle level. In the absence of evidence for new physics altering the high-mass di-lepton cross-sections, exclusion limits on various BSM models are set.

Misura della vita media effettiva del mesone B_s^0 nel decadimento raro in due muoni con l'esperimento ATLAS.

Raffaeli F.
Dipartimento di Fisica, Università di Roma Tor Vergata, Italia e INFN, Sezione di Roma 2, Università di Roma Tor Vergata, Italia

Il decadimento dei mesoni B^0 e B_s^0 in due muoni è fortemente soppresso nel Modello Standard in quanto mediato da processi di tipo FCNC. Per questo, oltre ai Branching Ratio di questi due decadimenti, anche la vita media effettiva del decadimento B_s^0 in due muoni è una quantità particolarmente sensibile a eventuali processi di nuova fisica. In questa presentazione verranno illustrati e discussi i risultati della misura di questa vita media effettiva ottenuta con i dati raccolti nel 2015–2016.

First inclusion of events involving hadronic τ leptons in the ATLAS $VH(b\bar{b})$ resolved analysis.

D'Anniballe G. ([1])([2]), Francavilla P. ([1])([2]), Di Gregorio G. ([3])([4])
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([2]) *INFN, Sezione di Pisa*
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([4]) *APC, Paris*

The observation of the Higgs boson decaying into a b-quark pair was a major success of the LHC-Run 2 data taking campaign. The leading sensitivity to this decay mode comes from events in which the Higgs boson is produced in association with a leptonically decaying vector boson. The analyses conducted so far only marginally involve τ-leptons. τ-particles can be produced via the $W(\tau\nu)H$ and $Z(\tau\tau)H$ production channels, generating five different final state signatures depending on the nature of the τ-lepton decay. This communication will summarize the status of the extensions of the analysis to include events with hadronic-τ in the measurement of the $pp \to V(\text{lept.})H(b\bar{b})$ process. These studies are part of the ongoing effort on the precise determination of the $pp \to V(\text{lept.})H(b\bar{b})$ process by the ATLAS Collaboration. Alternative analysis strategies exploiting the information on reconstructed hadronic τ leptons, designed to optimize the current ATLAS $VH(b\bar{b})$ measurements, will be shown as well as their expected improvements in terms of delivered signal strength precision and expected statistical significance.

Stato della produzione delle camere GEM per l'esperimento CMS al Large Hadron Collider.

Campagnola R.
INFN, Laboratori Nazionali di Frascati

Presentiamo lo stato della produzione delle camere Tripla-GEM per l'aggiornamento dell'esperimento CMS al Large Hadron Collider presso il CERN di Ginevra. La tecnologia usata per le camere si basa su l'utilizzo di GEM (Gas Electron Multiplier), fogli di Kapton ricoperti su entrambe le facce da un sottile strato di rame e micro-forati attraverso un processo di bagni chimici. Un opportuno campo elettrico applicato alle facce di rame permette di produrre un segnale elettrico attraverso un processo di amplificazione di carica all'interno dei microfori. Il progetto prevede la produzione di 72 "super-camere". La produzione è ripartita tra CERN e siti di produzione esterni. Il processo di produzione inizia con la ricezione dei materiali e con i controlli di qualità. Successivamente le varie componenti delle camere sono spedite presso i siti di produzione per ulteriori controlli di qualità e assemblaggio. Completati i test presso i siti di produzione, la camera è inviata al CERN per i test su stabilità ad alta tensione, integrazione dell'elettronica, cosmic test e assemblaggio finale. Al momento sono state assemblate 51 camere.

Beam-induced background mitigation strategies for a detector at high-energy muon collider.

Giraldin C. ([1])([2]), Lucchesi D. ([1])([2]), Buonincontri L. ([1])([2]), Giambastiani L. ([1])([2]), Zuliani D. ([1])([2]), Sestini L. ([2]), Casarsa M. ([3])
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([3]) *INFN, Sezione di Trieste*

Muon collider detector performance is critically related to the background produced by muon beam decays through the ring. It can be reduced by placing absorbers in the proximity of the interaction region, but an irreducible part arrives into the detector. It is therefore fundamental to mitigate the beam-induced background effects with an *ad hoc* detector design. We will report a study of beam-induced background effects at a center-of-mass energy of 3 TeV together with detector configuration and reconstruction algorithms description that allow to have high physics performance.

Picosec: Sviluppo di un rivelatore ad elevate prestazioni temporali per applicazioni al muon collider.

Brunoldi M. ([1]), Aimè C. ([1])([2]), Fiorina D. ([2]), Riccardi C. ([1])([2]), Salvini P. ([2]), Calzaferri S. ([2]), Vitulo P. ([1])([2]), Vai I. ([1])([2])
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([2]) *INFN, Sezione di Pavia*

I micropattern gaseous detector (MPGD) sono caratterizzati da ottime prestazioni in termini di risoluzione spaziale; tuttavia, presentano solitamente una modesta risoluzione temporale a causa delle fluttuazioni sulla posizione della prima ionizzazione nel gas. Picosec risolve questo problema basando il suo funzionamento sull'amplificazione, tramite una MicroMegas, di elettroni generati dalla conversione di luce Cherenkov prodotta da una particella incidente su un cristallo radiatore. Picosec raggiunge in questo modo risoluzioni dell'ordine della decina di ps, ed è stato proposto per operare in esperimenti ai futuri collider a muoni. L'obiettivo dello studio in corso è quello di ottimizzare questa tecnologia, valutando le prestazioni con diversi radiatori, diversi fotocatodi e diverse miscele di gas di nuova generazione, che abbiano anche un minor impatto ambientale. In questa comunicazione verrà presentato il rivelatore e gli aspetti che ne giustificano lo sviluppo. Saranno inoltre discussi i risultati recenti ottenuti dai test in laboratorio e con fasci di muoni, effettuati con diverse miscele di gas.

Risultati di un Test Beam per l'upgrade del Calorimetro Elettromagnetico di CMS per HL-LHC.

Orlandi F.
Università di Torino e INFN, Sezione di Torino

L'aggiornamento High-Luminosity dell'LHC al CERN fornirà una luminosità istantanea e integrata senza precedenti, con un numero medio di collisioni per bunch crossing di 140–200. Nella regione del Barrel del Calorimetro Elettromagnetico (ECAL) di CMS, l'intera elettronica di lettura e trigger verrà sostituita. I cristalli di tungstato di piombo e gli APD verranno mantenuti, ma la temperatura operativa sarà ridotta per mitigare il rumore indotto dalle radiazioni. I segnali saranno amplificati con doppio guadagno dal chip CATIA. L'ASIC LiTE-DTU li campionerà poi a 160 MHz, trasmettendoli dopo una compressione online e lossless. Le decisioni di trigger saranno eseguite off-detector dal Barrel Calorimeter Processor, costituito da FPGA potenti e flessibili. Con l'upgrade, ECAL fornirà prestazioni energetiche confrontabili con le attuali, migliorando notevolmente la risoluzione temporale. Durante la presentazione, saranno mostrati e discussi i risultati dell'ultimo test beam di ECAL. È stato il primo con l'intera catena elettronica installata su larga scala, con 200 cristalli esposti a un fascio di elettroni di energia variabile sulla linea H4 del CERN.

Modular symmetry and its role in the context of the flavor problem.

Meloni D.
Dipartimento di Matematica e Fisica, Università Roma Tre

In the past years, a substantial effort went into the understanding of fermion mixing and masses through flavour symmetries. While many models successfully describe the experimental data, there is no evidence in favor of one particular symmetry group. In this communication, I will review the main advantages of employing the recently proposed modular symmetry in correctly accounting for neutrino and quark masses and mixing.

Aula F8 - Maria Marinaro **ore 09:00 – 13:30**

Sezione II

Fisica della materia

Presiede: Calarco T. (Forschungszentrum Jülich, Universität zu Köln e Università di Bologna)

Relazioni su invito

▲ **Molecules in optical resonators: Precision measurements and fundamental tests.**

Gianfrani L.

Dipartimento di Matematica e Fisica, Università degli Studi della Campania "Luigi Vanvitelli", Caserta, Italy

The advent of visible and near-infrared optical frequency combs, at the beginning of the century, gave a tremendous boost to precision laser spectroscopy. This technology enables absolute measurements of atomic and molecular transitions frequencies, thus taking a key role for fundamental tests and measurements. Recently, high-precision spectroscopic investigations have been extended to the weak absorption features of light molecules for testing first principles variational calculations that include relativistic and quantum electrodynamic (QED) effects. In this respect, the small transition strength can be compensated by the use of long-path techniques. I will describe some examples of successful combination of cavity-enhanced spectroscopic methods and optical frequency comb synthesizers, for the aims of quantitative spectroscopy of linear molecules. I will report on recent results obtained at *Università degli Studi della Campania* regarding line-center frequency metrology and high-quality line-intensity determinations, in comparison with the most refined quantum mechanical calculations.

▲ **Bound states in the continuum in photonic crystal slabs: From polarization singularity to biosensing and emission enhancement.**

Zito G. ([1]), Romano S. ([1]), Rendina I. ([2]), Mocella V. ([1])

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([2]) *Institute of Applied Sciences and Intelligent Systems, National Research Council, Pozzuoli, Italy*

Large-area and transparent all-dielectric metasurfaces sustaining photonic bound states in the continuum (BICs) were exploited as a promising tool for many breakthrough applications. A BIC is a special mode in the energy continuum of free space waves that cannot couple with free-space radiation, which leads to a diverging radiative Q-factor and a topological singularity in the reciprocal space. Our group demonstrated several applications of BICs in photonic nanostructures: biological and chemical sensing with capability of detecting ultralow-weight molecules, surface amplification of fluorescence emission and Raman scattering, spin-optical transport. Here, we review some recent experimental results regarding spin-to-orbital angular momentum conversion at quasi-Dirac BIC, and several applications from ultrasensitive sensing and giant enhancement of upconversion luminescence.

▲ **Entanglement generation with Josephson metamaterials.**
Esposito M.
SPIN-CNR, Napoli
Josephson metamaterials are crucial tools in superconducting quantum technologies since they are typically adopted as Traveling Wave Parametric Amplifiers (TWPAs) allowing broadband and near quantum-noise–limited microwave detection. Remarkably, the potential of these devices goes also beyond amplification: they are extremely promising for the generation of broadband squeezing and multi-mode entanglement. In this talk, I will present experimental results on the generation of two-mode microwave entanglement with a Josephson metamaterial and discuss the perspectives of this work in the framework of microwave photonics with superconducting quantum devices.

▲ **Progresses in correlation plenoptic imaging.**
D'Angelo M.
Università degli Studi di Bari - Dipartimento Interateneo di Fisica e INFN Sezione Bari
Lightfiled imaging is an imaging modality enabling both to modify, in post-processing, the focused plane of acquired pictures and to perform scanning-free tridimensional imaging. The key is to retrieve both spatial and directional information about light from the scene of interest. In conventional approaches, this is done by means of a microns array, which enables to retrieve directional information at the expenses of spatial resolution. Despite the effective capabilities of conventional lightfield cameras are limited by their poor resolution, the fast 3D imaging capability of lightfield cameras is attracting increasing attention. We have proposed and developed a novel approach to plenoptic imaging, named correlation plenoptic imaging (CPI), which enables addressing the intrinsic resolution versus depth of field (DOF) trade-off by exploiting the peculiar spatio-temporal correlations of both chaotic and entangled photon sources. In this talk, I will present recent experimental achievements in CPI: from the first proof-of-principle demonstration of its diffraction-limited plenoptic imaging capability, to the implementation in the realm of microscopy, where diffraction-limited resolution has been combined with a 6× DOF, till the amazing acquisition speed-up enabled by the use of SPAD arrays. In fact, high-resolution volumetric imaging has been performed at 10 fps, and a further 30× seed-up has been achieved by means of deep learning.

Comunicazioni

● **Au/graphene quantum dots as sensor for highly sensitive electrochemical determination of glucose.**
Adami R. ([1])([2]), Cirillo C. ([1])([2]), Iuliano M. ([3]), Fierro F. ([1])([2]), Luciano C. ([1])([2]), Sarno M. ([1])([2])
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Diabetes is a metabolic disorder indicated by blood glucose concentrations, and causes with long-term damage and failure of various organs like heart, kidney, eyes, and blood vessels, ... The early and sensitive detection of abnormal glucose level in the blood is very important for proper treatment to reduce many health problems. Graphene quantum dots (GQDs) have become attractive for various applications, particularly in diagnostics, drug delivery, electronic displays, ..., due to its excellent electrical conductivity, biocompatibility, and transparency. Au is a promising semiconductor nanomaterial suitable to help GQDs in increasing the refractive index of the dielectric sensing media, which consequently increases the absorption of glucose. Herein, a simple and eco-friendly method to obtain

amino-functionalized Au nanoparticles/GQDs based on directly carbonization of citric acid for the preparation of a glucose sensor was reported. The sensing performance of the obtained nanosensor were tested, using a potentiostat/galvanostat, by cyclic voltammetry.

Optical calibration of standing wave acoustic levitator.

Marrara S. ([1])([2]), Ferretti S. ([3])([4]), Bronte Ciriza D. ([1])([2]), Magazzù A. ([2]), Caruso R. ([2]), Saija R. ([1])([2]), Foti A. ([2]), Gucciardi P.G. ([2]), Musolino A. ([5]), Folco L. ([6])([7]), Della Corte V. ([8]), Rotundi A. ([3]), Mandanici A. ([1])([2]), Maragò O.M. ([2]), Donato M.G. ([2])

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Acoustic levitation uses the forces arising from acoustic radiation pressure to counteract gravity and suspend both solid and liquid objects in the air. In this work, we use a standing acoustic wave levitator to trap multiple particles in the nodes of the acoustic wave. The calibration of the trapping forces is done by video microscopy, tracking the particle position fluctuations. Power spectra of the tracking signals can be used to calculate the spring constants. After the calibration using spherical particles and liquid drops, we present the results obtained by acoustically levitating sub-millimetric particles of extraterrestrial origin (*i.e.*, micrometeorite) and cometary dust analogues. The contactless manipulation shows the usefulness of acoustic tweezers for sample-return missions, for which contamination of the samples is still a key problem. The agreement between Agenzia Spaziale Italiana (ASI) and Istituto Nazionale di Astrofisica (INAF) n. 2018-16-HH.0, project "SPACE Tweezers" is acknowledged. This work has been also partially funded by European Union (NextGeneration EU), through the MUR-PNRR project SAMOTHRACE (ECS00000022) and PNRR MUR project PE0000023-NQSTI.

Artificial neural network analysis of VIS-NIR spectra in food and agriculture.

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Optical spectroscopy in the visible and near-infrared range (VIS-NIR) has recently become increasingly important in food, agricultural and forestry sciences due to instrumental small footprint, little or no sample preparation and large penetration depth (up to few mm). Due to the difficult interpretation of VIS-NIR optical spectra, the signal is usually elaborated by means of multivariate statistics and machine learning algorithms (chemometrics). Albeit accurate, these methods are usually non-transparent and it is often difficult to trace back the discriminant frequencies characterizing two different classes of samples. In this talk,

recent results obtained by the research group at CREA-IT in this field using artificial neural networks, will be presented. These algorithms appear accurate and robust. Moreover, thanks to a simple and accurate study of the features involved, it is possible to "open the box" and get a clear interpretation of the discriminating features involved.

Una spugna di TiO_2 per prevenire l'inquinamento da piombo nell'acqua.

Spampinato C. ([1])([3]), Valastro S. ([1]), Smecca E. ([1]), Mannino G. ([1]), Bongiorno C. ([1]), Fisicaro G. ([1]), Goedecker S. ([5]), Arena V. ([1]), Deretzis I. ([1]), Dattilo S. ([2]), Scamporrino A. ([2]), Carroccio S. ([2]), Fazio E. ([3]), Neri F. ([3]), Bisconti F. ([4]), Rizzo A. ([4]), Spinella C. ([1]), La Magna A. ([1]), Alberti A. ([1])

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L'utilizzo di materiali nanostrutturati, come il biossido di titanio (TiO_2), rappresenta una risorsa in molti campi di applicazione per migliorarne le funzionalità. Il TiO_2 per le sue proprietà è stato utilizzato in diversi ambiti, tra cui il fotovoltaico, la degradazione di inquinanti, super condensatori, dispositivi biomedici e batterie agli ioni di litio. In questo contesto, abbiamo sfruttato il metodo "Gig-lox", sviluppato al CNR-IMM, per depositare spugne di TiO_2 mediante sputtering reattivo basato su una geometria di incidenza radente combinata con ossidazione locale. La deposizione viene eseguita a temperatura ambiente all'interno di una camera ad alto vuoto e consente la deposizione di strati di ossido poroso su diversi materiali. La presenza di piombo nell'acqua è un problema ambientale direttamente legato alla salute e al benessere dell'uomo e dell'ecosistema. Il Gig-lox di nostra produzione si è rivelato un ottimo assorbitore di piombo. Nei test condotti abbiamo raggiunto un elevato livello di assorbimento di piombo di $63\,mg/cm^2$. Il nostro metodo, pronto per l'industrializzazione, permette di prevenire concretamente il rischio di rilascio di piombo nell'ambiente.

Orbital angular momentum beam generation in isotropic media.

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Photons of structured light can have quantized Orbital Angular Momentum (OAM). In the last years, the beams carrying OAM have largely attracted the attention of the scientific community. They are already used or have been proposed in several applications, such as optical tweezers, high-resolution imaging, lidar remote sensing, entangled quantum states for quantum key distribution (QKD) and multiplexed sources for free space communications. That is why the generation and detection of OAM is nowadays an active research area. Nowadays, there are several devices that allow to generate and manipulate OAM beams like spiral phase plate, spatial light modulator or q-plates. In this work we propose to generate OAM beams in isotropic media. Under certain conditions it is possible to exploit the photoelastic effect to produces a radial birefringence which results in a spin to orbital angular momentum conversion of the light beam passing through an isotropic medium, similarly to that happen in a q-plate. In our case the generation of OAM is produced by the photoelastic effect induced by the light itself.

Dissipative dynamics in the cavity-mediated energy transfer process between ultrastrong coupled devices.

Crescente A.
Dipartimento di Fisica, Università di Genova, Genova, Italia e CNR-SPIN, Genova, Italia

We analyze the coherent energy transfer process between a quantum charger and a quantum battery mediated by the photons in a resonant cavity. Exploiting a fully numerical analysis it is possible to consider both strong and ultra-strong coupling, which allows an improvement of the energy transfer performances compared to the limiting weak-coupling scenario. In particular, the ultra-strong coupling regime allows a faster energy transfer process and, even when the system is off-resonance, it allows to achieve an almost complete energy transfer. Moreover, in the present analysis the system is considered to be open and consequently affected by dissipation due to interactions with the environment. In particular, a lossy cavity can affect the dynamics of the system, therefore the study of the stability of the considered device in this condition is extremely important in view of possible experimental implementations.

Dynamical projective operatorial approach and its application to TR-ARPES signal.

Amir Eskandari-asl A., Avella A.
Università degli Studi di Salerno, CNR-SPIN, CNISM

New technological advancements facilitate probing systems pumped with ultra-short electromagnetic pulses. This demands new theoretical methods to simulate such pump-probe systems and explain the underlying physics of the observed phenomena. In this work, we present a method we recently developed, the Dynamical Projective Operatorial Approach (DPOA), and show how it can be applied to compute out-of-equilibrium Green's functions and, consequently, obtain the TR-ARPES signal. Additionally, we compute the non-equilibrium TR-ARPES spectra and give a counterpart of the fluctuation-dissipation theorem out of equilibrium. Moreover, we show how to unambiguously single out the effects of inter- and intra-band transitions and we compare our approach to the Houston method. We apply DPOA to a two-band toy model and, by a detailed study of the TR-ARPES signal, investigate the transient and residual effects of the pump on the excitations and energy bands, and the emergent different types of sidebands, depending on the pump and probe parameters and the symmetries in the k-space.

Generalized plasma waves in layered systems and their spectroscopic signatures.

Gabriele F., Udina M., Senese R., Castellani C., Benfatto L.
Sapienza University of Rome, Institute of Complex Systems, CNR

In a layered system the hybrid modes provided by the propagation of electromagnetic waves in the matter identify two well-separated energy scales connected to a large intra-layer and to a small inter-layer plasma frequency. Despite the wide interest in their detection and manipulation by means of various experimental protocols the physical ingredients underlying a unified description of plasma waves in such systems, valid at arbitrary energy and momentum, have been for long time poorly understood. In this talk I will review our recent progresses in the description of the nature and the spectroscopic signatures of what we named generalized plasma waves in layered systems. I will first focus on their general properties, showing that the anisotropy of the current response leads to two intertwined hybrid light-matter modes with mixed longitudinal and transverse character, while a purely longitudinal plasmon is only recovered for wavevectors larger than the crossover scale set in by the plasma-frequency anisotropy. In the second part I will discuss how such modes

emerge in EELS spectroscopy, that measures the density response at arbitrary energy and momentum.

Navigating at will on the water phase diagram.

Pipolo S. ([1]), Pietrucci P. ([2])
([1]) *Dept. of Chemistry Université de Lille, Lille*
([2]) *Dept of Physics, Sorbonne Université, Paris*

Despite the simplicity of its molecular unit, water is a challenging system because of its uniquely rich polymorphism and predicted but yet unconfirmed features. With a novel space of topology-based coordinates that capture changes in the interatomic network, we systematically track transitions among liquid, amorphous, and crystalline forms of the whole water phase diagram, including the challenging task of nucleation of crystals above and below the melting point. Our approach is based on molecular dynamics and enhanced sampling calculation techniques: mechanisms and free-energy surfaces are discussed for the homogeneous crystallisation of water at ambient conditions, and other phase transitions. We stress that our approach is not specific to water and we show that it can be applied to i) structural phase transitions in other materials like alumina ii) precipitation of salts in water.

Ambipolar electrical transport in metal-oxide core-shell nanowire heterostructures unveiled with ionic liquid gating.

Demontis V. ([1])([2]), Prete D. ([1]), Gilzad Kohan M. ([3]), Vomiero A. ([3]), Rossella F. ([4])
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([3]) *Department of Engineering Sciences and Mathematics, Luleå University of Technology, Sweden*
([4]) *Dipartimento di Scienze Fisiche, Informatiche e Matematiche, Università di Modena e Reggio Emilia, Modena, Italy*

Metal oxide (MO_x) semiconductors are popular materials in the field of optoelectronics due to their favorable electronic and optical properties. Controlling and tuning the electronic properties of these materials is essential for developing novel devices. Ion gating has emerged as a powerful tool to control the electronic properties of different classes of materials, such as oxides, organic semiconductors, and III-V semiconductor nanowires. This study investigates the transport properties of individual MO_x nanowires with radial *p*-*n* heterojunctions. These systems consist of a *p*-type Co_30_4 shell and an *n*-type ZnO core. Nanodevices are fabricated starting from individual nanowires and are equipped with a comb of electrodes allowing to probe selectively different operating configurations of the nanostructures, *i.e.* core-core, shell-shell and core-shell. The three sections display different responses, reflecting the properties of the individual materials as well of the heterojunction. Ion liquid gating, provides the key technique allowing to disclose the multifunctionality of our nanodevices.

Unveiling and veiling an entangled light-matter quantum state from the vacuum.

Stassi R.
Università degli Studi di Messina

The ground state of an atom interacting with the electromagnetic field in the ultrastrong coupling regime is composed of virtual photons entangled with the atom. We propose a method to promote to real the entire photonic state, while preserving the entanglement with

the atom. The process can be reversed, and the entangled state can be restored in the vacuum. We consider a four-level atom, with two of these levels ultrastrongly coupled to a cavity mode. The process is obtained by making use of either an ideal ultrafast pulse or a more realistic multi-tone pi-pulse that drives only the atom. An experimental realization of this proposal will not only enable the investigation of the exotic phenomena of emission of particles from the vacuum, but will also prove for the first time that quantum states can be extracted from the vacuum. Moreover, it will allow to inspect the ground state in the ultrastrong coupling regime, and to generate on-demand entangled states for quantum information processing.

Multiwalled WS_2 nanotubes forest for visible-light photodetectors.

De Stefano S. ([1]), Durante O. ([1])([2]), Capista D. ([3]), Passacantando M. ([3]), Zak A. ([4]), Giubileo F. ([2]), Camilli L. ([5]), Di Bartolomeo A. ([1])([2])
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([3]) *University of L'Aquila, L'Aquila, Italy*
([4]) *Holon Institute of Technology, Holon, Israel*
([5]) *University of Rome Tor Vergata, Rome, Italy*

One-dimension semiconductors are currently receiving much attention due to their unique electronic and optoelectronic properties. In particular, Transition Metal Dichalcogenides (TMDs) materials have become very fascinating owing to their layer-tunable bandgap, in terms of amplitude and its nature (direct or indirect). This makes them very promising for application in high-sensitivity, and ultra-fast photodetectors and phototransistors. In this work, we estimate the semiconductor behavior of a thin film of randomly oriented multi-walled tungsten disulfide nanotubes (WS_2NTs) drop-casted on an interdigitated electrode architecture, focusing on temperature response. We study the photocurrent dependence on both wavelength and pressure (*i.e.*, amplitude and relaxation times), and the effective bandgap of WS_2NTs forest. This analysis reveals a bandgap value of 1.87 eV, an increase in photocurrent compared to the single WS_2NT one, and different photocurrent values in several pressure conditions. Therefore, WS_2NTs are suitable for photodetection applications under a wide range of conditions.

Aula F4 - Henrietta Leavitt **ore 09:00 – 13:30**

Sezione III
Astrofisica
Presiede: Fusco A. (Università di Salerno)

Relazioni su invito

▲ **XENONnT dark matter experiment: recent results and next steps.**
Di Gangi P. on behalf of the XENON Collaboration
INFN - Sezione di Bologna
The XENONnT experiment was designed to look for dark matter particles and also for new, very rare phenomena thanks to unprecedentedly low background level. The core detector is a Dual-Phase Xenon TPC with a mass of 5900 kg of xenon constituting the active target for particle interactions. It is installed inside a water Cherenkov active muon and neutron veto, deep underground at the LNGS. XENONnT was constructed and subsequently commissioned between spring 2020 and spring 2021. XENONnT took the first science data over 97.1 days, from July 6 to November 10, 2021, for an initial exposure slightly larger than 1 tonne $\times$ year. The first results of XENONnT clarify an exciting excess observed by the predecessor XENON1T and set strong limits on new physics scenarios. A blind analysis of the same data sets new limits on interaction of WIMP dark matter with ordinary matter. Previous constraints are strengthened already with a first short exposure. XENONnT is collecting more data with improved radon removal system, aiming for further reduction of the neutron background thanks to the Gd-doped phase of the veto detectors, to increase the experimental sensitivity over the following years.

Comunicazioni

● **Neutron Veto of XENONnT: current status and performances.**
Mancuso A.
INFN sez. Bologna e Università di Bologna
The Neutron Veto of the XENONnT experiment is a gadolinium-loaded Water Cherenkov Detector designed to reduce the Nuclear Recoil background in the XENONnT Time Projection Chamber by detecting radiogenic neutrons from the detector materials. The Neutron Veto is instrumented with 120 high-QE, low-radioactivity Hamamatsu R5912 photomultiplier tubes, installed in a high light collection volume delimited by ePTFE reflector panels. In this talk, I will present the latest results of the Neutron Veto from the XENONnT Science Data, focusing on the current status and performance of the detector. Specifically, I will discuss the main parameters of the photomultiplier tubes and the neutron tagging efficiency. Although the data acquisition so far has been performed with demineralized water, the commissioning of the gadolinium Water Purification System is in an advanced stage. The insertion of gadolinium is expected to further enhance the neutron tagging efficiency, enabling to achieve an even lower background level for our dark matter search.

● **Ricerca di segnali di materia oscura negli spettri energetici dei raggi gamma galattici con 13,75 anni di dati del Fermi-LAT.**
Giliberti M. ([1])([2]), Mazziotta M.N. ([1]), Loparco F. ([1]), Serini D. ([1])
([1]) *INFN - Sez. di Bari*
([2]) *Politecnico di Bari*
Nonostante vi siano varie evidenze sperimentali sull'esistenza della materia oscura, il dibattito sulla sua natura è ancora aperto. Una classe di possibili candidati è rappresentata dalle

Weak Interacting Massive Particles (WIMP). La nostra galassia è in gran parte composta da materia oscura. Supponendo che coppie di WIMP possano annichilarsi producendo raggi gamma, o che le WIMP possano decadere direttamente in fotoni, si dovrebbero osservare righe monocromatiche nello spettro dei raggi gamma galattici. Per cercare tali righe abbiamo analizzato gli spettri dei raggi gamma provenienti dalla nostra galassia, costruiti utilizzando un campione di dati raccolti dal Fermi-LAT nell'intervallo di energia 1 GeV–1 TeV nei primi 13,75 anni di presa dati. La ricerca è stata effettuata in 5 regioni del cielo, ottimizzate per diversi profili di materia oscura, e non ha fornito evidenza di segnali significativi. Si sono quindi ottenuti dei limiti superiori sulla sezione d'urto di annichilazione e sul rate di decadimento delle WIMP.

L'esperimento CYGNO, una TPC direzionale con lettura ottica per la ricerca di materia oscura.

Meloni P. on behalf of the CYGNO Collaboration
Università degli Studi Roma Tre e INFN

Il progetto CYGNO vuole costruire un rivelatore per il tracciamento 3D ad alta precisione dei rinculi nucleari a bassa energia indotti da materia oscura e da neutrini. L'obiettivo è ricostruire le tracce da ionizzazione in un volume gassoso per avere sensibilità alla direzione delle particelle osservate. Il rivelatore proposto per CYGNO è una TPC a 1 atm riempita con una miscela gassosa di He:CF4 60/40. L'amplificazione della ionizzazione è data da un piano di triple GEM e la luce prodotta nella moltiplicazione viene letta da sensori sCMOS e da fotomoltiplicatori per la ricostruzione 3D. Il prototipo LIME è una TPC con una regione di deriva di 50 cm e un volume di 50 L. Dopo un periodo di test ai LNF, il prototipo è ora in presa dati ai LNGS per misurarne le prestazioni, il livello di radioattività interna e il flusso di neutroni nel sito sperimentale. La collaborazione si appresta a costruire CYGNO-04, una TPC di 0,4 m^3, per dimostrare la scalabilità delle tecniche sperimentali. Si propone di presentare lo stato degli studi del fondo per LIME presso i LNGS, assieme ai risultati sulla risoluzione energetica, la stabilità del rivelatore, e il confronto dati-simulazione.

Latest results from the DAMPE space experiment.

Cagnoli I. on behalf of the DAMPE Collaboration
Gran Sasso Science Institute GSSI, L'Aquila, Italy e INFN, Laboratori Nazionali del Gran Sasso, L'Aquila, Italy

The Dark Matter Particle Explorer (DAMPE) is a space-based particle detector operating onboard China's Space Station since December 17th 2015. The main scientic objectives are to search for possible Dark Matter signatures in the cosmic electron and gamma-ray spectra, to directly measure the flux and composition of cosmic protons and heavier nuclei up to hundreds of TeV and to perform high energy gamma-ray astronomy. In this talk, I will present the DAMPE latest results focusing on the precise measurements of the galactic cosmic ray fluxes which are of particular interest for studying the mechanisms of acceleration and propagation in our Galaxy. An overview of the cosmic ray spectra analyses will be given, discussing new spectral features that have been revealed in the all-electron, proton and helium spectra as well as in the boron-to-carbon and boron-to-oxygen ratios.

DarkSide-20k: direct dark matter search with 50 t of underground argon.

Matteucci G. ([1])([2]), Fiorillo G. ([1])([2])on behalf of the Darkside Collaboration
([1]) *Dipartimento di Fisica, Università degli Studi di Napoli Federico II, Italia*
([2]) *INFN Napoli, Italia*

The construction of DarkSide-20k (DS-20k), the next programmed experiment from the GADMC (Global Argon Dark Matter Collaboration) is ongoing at Gran Sasso Underground

Laboratories (LNGS). DS-20k will feature a 50 t dual-phase argon time projection chamber to search for DM-Nucleon elastic scattering with unprecedented sensitivity to cross-sections equal to 6.3×10^{-48} cm^2, corresponding to the 90% C.L. exclusion limit for a WIMP mass of 1 TeV/c^2 for a 200 t yr exposure in the 20 t fiducial volume. The argon employed in the experiment will be extracted from an underground source (located in Cortez, Colorado) chosen for its reduced abundance of the beta-emitter ^{39}Ar isotope. DS-20k will be equipped with low-radioactivity SiPM-based photodetectors with high photon-detection efficiency and a neutron veto system based on Gd-loaded acrylic panels for neutron moderation and capture. In this talk, the current status of the experiment construction will be reported, with insights on the topics of photo-electronics, argon procurement and production of the TPC.

Search for Dark Matter annihilation in the Sun using 13 years of ANTARES data.

Poirè C. on behalf of the ANTARES Collaboration
Dipartimento di Fisica "E.R. Caianiello", Università degli Studi di Salerno

One of the current hardest challenges in Physics today is to establish the nature of dark matter and, among the different candidates, Weakly Interacting Massive Particles (WIMPs) are very popular. These particles can be gravitationally captured into massive celestial objects, in which they can annihilate between themselves into Standard Model particles, also yielding neutrinos. The centre of those massive objects is, therefore, a target for a search for a neutrino excess from dark matter annihilation using neutrino telescopes. The Sun could be one of these targets: it is massive, its lifetime is long enough to produce an equilibrium between capture and annihilation processes of dark matter particles, and the astrophysical background is well known. In this work the limits obtained with data recorded by ANTARES, a neutrino telescope located in the Mediterranean Sea, from 2007 to the end of 2019 searching for muon neutrinos originating from dark matter annihilation in the Sun are presented. No signal above the expected background has been found and upper limits on the WIMP-proton interaction cross sections have been obtained.

The Galileo for Science (G4S_2.0) project: constraints on the possible presence of dark matter in the Milky Way with the atomic clocks of the Galileo FOC constellation.

Sapio F. ([1])([2]), Cinelli M. ([1]), Di Marco A. ([1]), Fiorenza E. ([1]), Gatto N. ([1]), Lefevre C. ([1]), Loffredo P. ([1]), Lucchesi ([1]), Lucente M. ([1]), Magnafico C. ([1]), Peron R. ([1]), Santoli F. ([1]), Visco M. ([1]), Vespe F. ([3])
([1]) *Istituto di Astrofisica e Planetologia Spaziali, Istituto Nazionale di Astrofisica, Tor Vergata, Roma*
([2]) *Dipartimento di Fisica G. Marconi, Università degli studi di Roma Sapienza, Roma, Italia*
([3]) *ASI-Centro di Geodesia Spaziale, Matera, Italia*

G4S_2.0 is an ongoing project funded by the Italian Space Agency which aims to perform measurements in the field of Fundamental Physics with the navigation satellites of the European Galileo-FOC constellation. One of the key aspects is the presence of precise atomic clocks on board the satellites. After a general introduction to the main objectives of G4S_2.0, the preliminary activities developed at IAPS-INAF in Rome concerning the measurement strategy and the consequent constraints on the presence of Dark Matter in the galaxy's halo will be presented. These activities are focused on the analysis of the clock biases of the atomic clocks estimated for each satellite of the constellation by a precise orbit determination and their comparison with on-ground reference clocks.

Caratterizzazione di segnali da rinculo nucleare a bassa energia nella LAr TPC dell'esperimento ReD.

Pino N. ([1])([2]), Albergo S. ([1])([2]), Gulino M. ([3])([4]), Pandola L. ([3]), Puglia S. ([1])([2]), Sanfilippo S. ([3]) e il gruppo dell'esperimento ReD
([1]) *Dipartimento di Fisica, Università degli Studi di Catania, Italia*
([2]) *INFN - Sezione di Catania, Catania, Italia*
([3]) *INFN - Laboratori Nazionali del Sud, Catania, Italia*
([4]) *Università di Enna Kore, Enna, Italia*

L'esistenza di Materia Oscura come residuo termico del Big Bang potrebbe essere provata osservando l'interazione di particelle massive debolmente interagenti (WIMP) con la materia. La collaborazione DarkSide, nell'ambito della Global Argon Dark Matter Collaboration (GADMC), vuole estendere la ricerca di WIMP anche a masse < 10 GeV/c^2 usando una Camera a Proiezione Temporale (TPC) bifasica ad argon liquido (LAr). A questi valori di massa, le WIMP darebbero rinculi nucleari con energie tra 1 e 10 keV$_{nr}$. In tale intervallo di energia si ha una bassa efficienza di rivelazione della luce di scintillazione e lo studio della risposta in carica del detector risulta cruciale per il futuro esperimento DarkSide-20k. In tale contesto, l'esperimento Recoil Directionality (ReD) è impegnato in una campagna di misure presso la Sezione INFN di Catania. La misura è condotta producendo rinculi nucleari nell'intervallo di energia di interesse nella TPC di ReD tramite i neutroni emessi da una sorgente di ^{252}Cf e rivelati a valle da uno spettrometro composto da una matrice di 18 scintillatori plastici. Questo contributo tratta il nuovo apparato sperimentale e le strategie di rivelazione.

Constraining the searches for the missing universe with ALICE.

Calivà A.
University of Salerno e INFN

Dark matter is a mysterious and elusive form of matter in our Universe of which we can only measure gravitational effects. According to the most accredited theoretical models, dark matter particles in our galaxy might annihilate and produce standard model particle-antiparticle pairs which, traveling through the galaxy, can reach the Earth and be detected by space-borne experiments such as AMS-02 or GAPS. Nuclei-antinuclei pairs are promising probes for indirect dark matter detection due to their rare production rate in inelastic collisions between cosmic rays and the interstellar medium. In this talk, recent ALICE measurements of (anti)nuclei production in pp collisions and of antinuclei inelastic cross section will be presented. These results are used to constrain the flux of secondary antinuclei from cosmic ray interactions by modeling their production rate and absorption term in the propagation equation. The current precision of the antinuclei inelastic cross section measurements is expected to be improved in Run 3 using a dedicated experimental setup installed in ALICE whose expected performance will be shown.

Associazione di segnali ottenuti da fotocamera sCMOS e PMT per la ricostruzione 3D di tracce in una TPC.

Borra F.
Dipartimento di Fisica, La Sapienza Università di Roma, Italia e INFN sezione di Roma, Italia

La ricerca di eventi rari, come la materia oscura o il neutrino sterile, richiede tecniche sperimentali innovative. La collaborazione CYGNO intende sviluppare una Time Projection Chamber di grandi dimensioni basata sulle GEMs per l'amplificazione e su una fotocamera sCMOS e dei PMTs per la lettura del segnale. Questo sistema consente una ricostruzione 3D delle tracce fino ad energie di pochi keV, permettendo di discriminare rinculi nucleari da rinculi elettronici. Verrà discusso l'innovativo algoritmo basato su un fit bayesiano per inferire

posizione ed energia rilasciata dell'evento utilizzando la sola carica raccolta dai PMTs. Sarà discussa la procedura di calibrazione basata su eventi indotti da una sorgente di ^{55}Fe, e le prestazioni in termini di efficienza e risoluzione. Verrà illustrata anche la strategia con cui si combinano le informazioni xy ricostruite con la fotocamera con l'informazione temporale dei PMT per inferire la terza coordinata ottenendo una ricostruzione 3D. Questo lavoro presenta i risultati basati sull'analisi dei dati acquisiti con il prototipo LIME durante la campagna underground presso i Laboratori Nazionali del Gran Sasso nel 2022/23.

Neutrino reconstruction analysis at ICARUS detector.

Artero Pons M.
INFN Sezione di Padova e University of Padova, Padova, Italy

Liquid Argon Time Projection Chamber (LArTPC) detectors offer charged particle imaging capability with impressive spatial resolution. Precise event reconstruction procedures are mandatory in order to fully exploit the potential of this technology. After a successful three-year physics run at the underground LNGS-INFN laboratory, ICARUS was refurbished and subsequently moved to Fermilab to begin to operate as the far detector in the Short-Baseline Neutrino Program (SBN). ICARUS has entered the physics run phase and is presently collecting large statistical samples for its proposed physics analysis program. In this presentation we will show ICARUS event selection, reconstruction and analysis algorithms that are currently being used. First studies have been performed with a well-defined sample of ν_μ *CC* quasi elastic interactions, showing promising and robust results of fully reconstructed neutrino events. Detailed investigations are undergoing on particle identification, particle *vs.* shower distinction, calibration corrections and many other topics, which will be reported here. To conclude an up-to-date summary of the ICARUS analysis startup will be given.

Probing Neutrino Oscillations with JUNO.

Cerrone V.
Università degli Studi di Padova, Italy e INFN Padova, Italy

The Jiangmen Underground Neutrino Observatory (JUNO) is a multipurpose neutrino experiment currently under construction in southern China. The detector consists of a 20 kton liquid scintillator target, contained inside a 35-meter-diameter spherical acrylic vessel. JUNO's main goal is the determination of the neutrino mass ordering (MO) at high statistical significance (3–4 σ in 6 years of data taking), by measuring flavor oscillations of electron antineutrinos emitted from two adjacent nuclear power plants, located on a 53 km baseline from the experimental site. JUNO will be able to measure with sub-percent precision three oscillation parameters: $\sin^2(\theta_{12})$, Δm^2_{21}, Δm^2_{31}. Moreover, it will be the first experiment to simultaneously probe the effects of solar (Δm^2_{21}) and atmospheric (Δm^2_{31}) oscillations. This contribution will focus on the oscillation physics potential of JUNO, with a particular emphasis on reactor antineutrino analysis. Some results on JUNO sensitivity to the atmospheric mass splitting Δm^2_{31} will also be presented.

JUNO sensitivity to ^{7}Be, pep and CNO solar neutrinos.

Coletta C.
Dipartimento di Fisica, Università degli Studi di Milano e INFN Milano

JUNO (Jiangmen Underground Neutrino Observatory) is a neutrino detector currently under construction in China and expected to start data-taking in 2025. In my presentation I will discuss one of JUNO's main goals: the spectroscopy of solar neutrinos. It will be performed by observing the solar neutrino-electron scattering with 20 kt of high-radiopurity liquid scintillator. JUNO, with its high scintillating mass and excellent energy resolution, could be a key player in resolving some of the open questions in the field, like the solar

metallicity problem or possible non-standard interactions. JUNO is expected to improve significantly the current accuracy in ^{7}Be neutrinos' measurements, while additional techniques to exclude radioactive backgrounds will be needed to improve the measurement of pep and CNO neutrinos. I will also discuss in further detail the possibility of using the directionality of Cherenkov light produced by the scattered electron to distinguish between neutrino events and radioactive beta decay.

Purposes and status of the JUNO detector.

Senatore G.
Università degli Studi di Milano e INFN Milano

JUNO (Jiangmen Underground Neutrino Observatory) is a neutrino experiment under construction in the underground laboratory of Kaiping (Guangdong, China) and expected to be completed in 2025. JUNO will be a huge liquid scintillator detector, with a central vessel of 35.4 m filled with 20 kton of LAB-based scintillator and equipped with more than 43000 PMTs. With its ambitious design, JUNO aims at the determination of the neutrino mass ordering at high statistical significance (3-4 σ in about 6 years of data taking). JUNO will target an unprecedented 3% energy resolution at 1 MeV scale, crucial for measurement of the oscillation pattern of electron antineutrinos generated by two nuclear power plants, on a 53 km baseline from the experimental site. Besides its main goal, JUNO aspires to the measurement of atmospheric neutrinos, to solar neutrino precision spectroscopy, and to the detection of low-energy neutrinos coming from supernovae and geo-neutrinos. In this talk, the JUNO detector purposes, design and the status of the experiment construction will be presented.

Studio di violazione dell'invarianza di Lorentz con il rilevatore ORCA di KM3NeT.

Malerba L. ([1])([2]), Domi A. ([2]), Tosi S. ([1])([2]), Sanguineti M. ([1])([2])
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([2]) *INFN, Sezione di Genova, Italia*

L'invarianza di Lorentz è una simmetria della natura che esprime la proprietà di indipendenza delle leggi fisiche rispetto all'orientamento e alla velocità del sistema di riferimento considerato; esistono teorie che prevedono la violazione di tale simmetria in specifici regimi che sarà possibile testare con esperimenti di prossima generazione. Nella mia presentazione illustrerò alcuni studi preliminari svolti dell'ambito della fisica dei neutrini avvalendomi di simulazioni del rivelatore ORCA dell'esperimento KM3NeT, un telescopio di neutrini in costruzione nel Mar Mediterraneo. Il rilevatore è utilizzato per lo studio dei neutrini atmosferici col fine di definirne le proprietà fondamentali che ne regolano l'oscillazione; lo scopo finale successivo di queste ricerche è la caratterizzazione della violazione dell'invarianza di Lorentz nell'ambito dello Standard Model Extension.

Controlling the KM3NeT Data Acquisition System.

Bozza C. on behalf of the KM3NeT Collaboration
University of Salerno e INFN Gruppo Collegato di Salerno

The talk presents the Control Unit of the KM3NeT neutrino telescopes. The detector state machine, the setting of all the required parameters, such as voltages, thresholds, together with all the instruments that monitor the operation are steered by the Control Unit software, which also orchestrates the tasks of the computers involved in the triggering and data acquisition system. The Control Unit is a suite of programs that is flexible, for detectors made of a varying number of elements and devices from different epochs, versions and firmware. In addition, to exploit the features of KM3NeT as a multidisciplinary science infrastructure,

devices to monitor water properties and marine biology are being installed. The Control Unit has a strongly optimised, scalable and fault-tolerant design, which allows adding computing power incrementally and also operation in downgraded modes in case of failure of one or more control or processing machines. Robust forecasts support the confidence that even a single server will be able to bear the load of controlling such complex telescopes, and just a few more resources would ensure a livetime close to 100%.

Machine learning in KM3NeT.

Spisso B. ([1]), Domi A. ([2]), Filippini F. ([3])([4]), Androutsou E. ([5])
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The KM3NeT neutrino detectors are currently taking data while undergoing construction in two locations in the Mediterranean Sea. KM3NeT/ARCA is a large-scale Cherenkov detector located southeast off the Sicily, using several megatons of seawater monitored by photo-sensors, aiming at investigating astrophysical high-energy neutrino sources in the universe. KM3NeT/ORCA is the low-energy detector of KM3NeT, located off the French coast with a smaller and denser network of photo-sensors; its main goal is the study of neutrino including the determination of the neutrino mass ordering. This talk aims at demonstrating the general applicability of neural networks to neutrino telescopes, using simulated datasets for KM3NeT/ARCA. GNNs (graph neural networks) are employed to accomplish reconstruction as well as classification tasks for neutrino events, promising an alternative to the very time-consuming analysis based on maximum-likelihood methods. Some GNNs will be described, which have proved to provide good performance, *e.g.*, for the classification, the energy and the direction estimation of the incoming neutrino. For completeness, a report is also given of the machine learning tasks in ORCA.

Neutrini da supernova con l'esperimento RES-NOVA.

De Santis A.L.
Gran Sasso Science Institute, Italy

Le core-collapse Supernovae (SNe) sono tra gli eventi più energetici dell'Universo, durante i quali gran parte dell'energia della stella viene rilasciata sotto forma di neutrini. Queste particelle permettono di accedere direttamente ai processi che avvengono all'interno del nucleo stellare. Un processo particolarmente interessante per rivelare questi neutrini astrofisici è lo scattering elastico coerente neutrino-nucleo (CEνNS). Esso è caratterizzato da una altissima sezione d'urto e una segnatura che popola lo spettro energetico del rivelatore nella regione del keV. L'esperimento RES-NOVA si propone di rivelare questi neutrini utilizzando il CEνNS tramite un approccio rivoluzionario: un array di rivelatori criogenici. RES-NOVA, per soddisfare le richieste sperimentali, prevede di utilizzare come assorbitori dei cristalli di $PbWO_4$ operati a temperature dell'ordine delle decine di mK. Il piombo, oltre ad essere un bersaglio adatto per i neutrini perché ne massimizza la sezione d'urto per CEνNS, sarà archeologico, garantendo un bassissimo fondo nella regione di interesse. Nel mio contributo introdurrò il caso di fisica, l'esperimento ed i risultati delle prime misure di test.

Alla ricerca del doppio decadimento beta senza neutrini nel germanio-76: prime analisi dei dati di LEGEND.

Saleh G.
Dipartimento di Fisica e Astronomia, Università degli Studi di Padova, Italia e INFN, Sezione di Padova, Italia

Il doppio decadimento beta senza neutrini ($0\nu\beta\beta$) è un processo raro che può avvenire solo se il neutrino è un fermione di Majorana. Se osservato, questo decadimento farebbe quindi luce sulla natura del neutrino e costituirebbe un'evidenza sperimentale della violazione del numero leptonico, fenomeno non previsto dal Modello Standard. Inoltre, dallo studio di questo decadimento è possibile ricavare informazioni riguardanti la massa dei neutrini. L'esperimento LEGEND (Large Enriched Germanium Experiment for Neutrinoless double beta Decay) ricerca il decadimento $0\nu\beta\beta$ del ^{76}Ge utilizzando rivelatori al germanio arricchiti in ^{76}Ge. Nella sua prima fase, realizzata ai Laboratori Nazionali del Gran Sasso, saranno messi in opera 200 kg di germanio, con i quali la sensibilità attesa per il tempo di dimezzamento del decadimento è di oltre 10^{27} anni; l'obiettivo della seconda fase è di mettere in opera 1 ton di germanio, per una sensibilità di oltre 10^{28} anni. Il lavoro presentato si incentra sullo studio dei dati raccolti durante la fase di commissioning dell'esperimento, con 60 kg di germanio.

Aula F3 - Maria Telkes **ore 09:00 – 13:30**

Sezione IV
Geofisica e fisica dell'ambiente
Presiede: Lapenna V. (IMAA-CNR)

Relazioni su invito

▲ **Global Navigation Satellite Systems: A review from the creation of a monitoring network to the data analysis and the interpretation of the relative results.**
Avallone A.
Istituto Nazionale di Geofisica e Vulcanologia
During the last 20 years, we observed a growing number of permanent GPS networks developed for monitoring the evolution of the deformation at different spatial scales in active tectonics and volcanic areas. Thanks to the continuous instrumentation's development, the frontiers of the studies on the deformation have been pushed also at different temporal scales, *i.e.*, from years to seconds (and even below) for observing and modeling earthquake sources or dike intrusions and for early warning applications. The capability to observe a target geophysical phenomenon strongly depends on the effort for planning the monitoring network and on the characteristics of the chosen instrumentation. Further steps are represented by the data analysis and the interpretation of the results. Different GPS data analysis strategies can be adopted for monitoring the deformation of a given target (PPP, DD, RTK). All these strategies have their pros and cons to know, in terms of accuracy, for an actual, aware and rigorous interpretation of the results. A review of some science-driven GPS monitoring networks, of data analysis strategies and their relative accuracies and results will be shown.

▲ **Seismic attenuation in the Gargano Promontory (Southern Italy).**
Filippucci M. ([1]), de Lorenzo S. ([1]), Del Pezzo E. ([2])([3]), Lucente S. ([1]), Tallarico A. ([1])
([1]) *Department of Earth and Geoenvironmental Science, University of Bari Aldo Moro, UniBa, Bari, Italy*
([2]) *National Institute of Geophysics and Volcanology, INGV, Italy*
([3]) *Instituto Andaluz de Geofisica, Universidad de Granada, Granada, Spain*
Since 2013 UniBa and INGV have been collaborating for the operation of the OT seismic network which has significantly improved the seismic monitoring of Southern Italy and Gargano Promontory (GP). The seismic monitoring revealed an intense activity of micro-earthquakes with magnitude less than 2.8 and hypocenters clustered at different depths down to 30 km. Recent 2D and 3D seismic attenuation imaging revealed the trend of coda quality factor Q_c that can be correlated with other geophysical observations in the area. To understand whether Q_c is related to anelasticity or to heterogeneities of the GP crust, the separation of the contribution of intrinsic and scattering quality factors to Q_c is essential. Here we present the quality factors of the P and S waves, Q_α and Q_β, obtained from the coda normalization method. $Q_\alpha > Q_\beta$ can be related to the presence of crustal fluids under conditions of partial saturation for the crustal rock volumes under seismic sampling. The backprojection of Q_α and Q_β along seismic rays allowed to get a 3D image of $\frac{Q_\alpha}{Q_\beta}$ to be related to fluid percolation and low/high attenuating bodies.

Comunicazioni

A new tool for Real-Time GNSS data analysis starting from RING network data acquisition.

Miele P. ([1]), Avallone A. ([1])([2]), D'Ambrosio C. ([1]), Falco L. ([1]), Jiang X. ([3]), Ge M. ([3]), Xie W. ([3]), Cecere G. ([1]), Devoti R. ([2]), Famiglietti N.A. ([1]), Grasso C. ([1]), Pietrantonio G. ([2]), Vicari A. ([1])

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([2]) *Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Nazionale Terremoti, Rome, Italy*
([3]) *Deutsches GeoForschungsZentrum, GFZ, Wissenschaftpark "Albert Einstein", Potsdam, Germany*

Considering its ~ 250 real-time transmitting remote sites, the INGV RING GNSS network allows to measure deformation at different spatial and temporal scales in the Eurasia-Africa plate boundary region. The data streaming is managed by the acquisition centres in Southern Italy (Grottaminarda, AV) and the synchronization between the sourcetable (metadata) and the RING database guarantees reliable real-time products. GNSS data analysis has been performed by using the RTPPP software developed by GFZ (EWRICA project; Ge *et al.*, 2012). The software allows obtaining PPP products with increasing accuracy (standard PPP, PPP-AR and PPP-RA, Ge *et al.*, 2012). On 24 h data, the ambiguity resolution (PPP-AR) allows accuracies of 1 and 2 cm for the horizontal and vertical components, respectively, at the best sites. Moreover, the application of regional augmentation (PPP-RA) ensures even better accuracies in the real-time products. In addition, an algorithm to detect co-seismic static offsets from real-time time series has been implemented. The first outcomes make the RING a crucial contribution to warning systems in case of low-to-moderate (M 5.5–6.5) earthquakes in Italy.

Analisi comparativa sulle deformazioni locali tra le stazioni GNSS ed il giroscopio laser Gingerino.

Di Somma G.
INFN, Sezione di Pisa

Nella geodesia, l'individuazione di deformazioni locali è un tema molto sentito e quindi nella nostra analisi abbiamo confrontato il segnale di due strumenti in grado di rivelarle: Gingerino, e le stazioni GNSS; quest'ultime sono state selezionate in modo omogeneo intorno alla posizione di Gingerino. Per l'analisi comparativa abbiamo ricavato la componente rotazionale dell'area circoscritta dalle stazioni GNSS e l'abbiamo confrontata con il segnale di Gingerino. Abbiamo utilizzato due metodi diversi. Nel primo si ricava la componente rotazionale di ogni singola stazione, utilizzando la posizione di Gingerino come polo, e poi si fa una media ponderata per ottenere il vettore di rotazione associato all'area circoscritta dalle stazioni. Nel secondo metodo, si calcola la componente z del rotore, visto dall'intera costellazione di stazioni, nel punto in cui è posizionato Gingerino. Le coerenze tra i segnali provenienti dai due diversi metodi ed il segnale di Gingerino mostrano strutture simili che superano anche il 60% di coerenza nel periodo 6–15 giorni.

Frequency analysis of InSAR time series.

Ruzza G., Vicari A.
Istituto Nazionale di Geofisica e Vulcanologia, Sezione Irpinia, Grottaminarda, Italy

The use of Synthetic Aperture Radar (SAR) satellite technology as an indirect geodetic tool for measuring the deformation of the Earth's surface has been increasingly used in recent decades, thanks to its important applications in both scientific fields as a support

for understanding deformation processes, also at large scales, and as a monitoring tool for the protection of populations and structural assets. In particular, the analysis of displacement time-series data of a specific area over time allows for the understanding and study of deformation dynamics, enabling the analysis of both their static and cyclic components. The experimental application of frequency analysis to InSAR time series data, applied to a case study of surface deformation covering an area of approximately 12432 km^2 between Campania, Basilicata, and Puglia, has allowed the separation of deformation into different components based on their characteristic cyclic period. This has enabled a simpler interpretation of the individual deformation contributions, characterized by different periodicities that are simultaneously active and therefore contribute to the total deformation dynamics of the observed area.

Comparison between two important events occurred in the Tonga-Kermadec subduction zone: June 15, 2019 M7.2 Kermadec Islands earthquake and January 15, 2022 Hunga Tonga-Hunga Ha'apai eruption.

D'Arcangelo S. ([1])([2]), Regi M. ([1]), De Santis A. ([1]), Fidani C. ([1]), Perrone L. ([1]), Piscini A. ([1]), Soldani M. ([1]), Cianchini G. ([1]), Sabbagh D. ([1])

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([2]) *Department of Physics of the Earth and Astrophysics, Faculty of Physics, Universidad Complutense de Madrid, Madrid, Spain*

One of the most active areas for the subduction continuous processes is the Tonga-Kermadec zone. Recently, two important geophysical events took place there: in 2019, an M7.2 earthquake with the epicentre in Kermadec Islands (New Zealand) and, in 2022, an unprecedented eruption of Hunga Tonga-Hunga Ha'apai (HTHH) volcano. We focused on the analysis of any effect before, during, and after each event with a multi-parametric and multi-layer approach to study the geodynamic of the entire area based on the Lithosphere-Atmosphere-Ionosphere Coupling (LAIC) models. In detail, we conducted a seismic analysis of both sequences of phenomena, culminating with the corresponding disruptive event, centring our attention in the respective Dobrovolsky area. We detected various anomalies in the atmospheric parameters like temperature, pressure and presence of gases connected to the events. Finally, Ultra Low Frequency (ULF) magnetic field changes and electron burst precipitations were observed from Low Earth Orbit (LEO) satellites above the Pacific. All these observations give us a better insight of the complex tectonic context.

Struttura della crosta e anisotropia nel Promontorio del Gargano: Risultati preliminari da Receiver Function (RF) delle stazioni sismiche OTRIONS.

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Il monitoraggio sismico del Promontorio del Gargano ha avuto uno sviluppo importante dal 2013 grazie alle iniziative congiunte di DIST-GEO e INGV nell'ambito di progetti europei. Questi hanno portato alla realizzazione e al successivo sviluppo della rete OTRIONS (OT) e parallelamente sono state avviate ricerche per caratterizzare e comprendere la sismicità che è confinata principalmente nella crosta inferiore. In questa presentazione si

farà una disamina delle questioni scientifiche aperte dai precedenti studi sulla distribuzione della sismicità, attenuazione e caratteristiche reologiche per mostrare i motivi per cui abbiamo iniziato il lavoro sulle Receiver Functions delle stazioni OT. Il dataset è composto da circa 3000 telesismi avvenuti nel periodo 2013–2021 con magnitudo maggiore di 5.0 e registrati da 20 stazioni della rete OT a corto periodo e dalla Rete Sismica Nazionale a larga banda. I risultati preliminari forniscono informazioni sulla struttura e anisotropia della crosta e costituiscono il punto di partenza per modellare quantitativamente le sue proprietà reologiche, di interpretarne la sismicità e, in ultimo, fornire indicazioni sulla pericolosità sismica.

The DEnse mulTi-paramEtriC observations and 4D high resoluTion imaging (DETECT) experiment: Preliminary results.

Stabile T.A. ([1]), Scotto di Uccio F. ([2]), Muzellec T. ([2]), Picozzi M. ([2]), Bindi D. ([3]), Cotton F. ([3]), Festa G. ([2])([1]), Strollo A. ([3]), Zollo A. ([2]), Adinolfi G.M. ([4])([10]), Martino C. ([5]), Amoroso O. ([6]), De Matteis R. ([4]), Convertito V. ([5]), Spallarossa D. ([7]), Caruso A. ([2]), Carotenuto F. ([2]), Cololmbelli S. ([2]), De Landro G. ([2]), De Martino G. ([1]), Elia L. ([2]), Gueguen E. ([1]), Heit B. ([3]), Hillmann L. ([3]), Iaccarino A.G. ([2]), Lovikness K. ([3]), Mroczek S. ([3]), Nazeri S. ([2]), Muzellec T. ([2]), Napolitano F. ([6]), Panebianco S. ([1])([8]), Rea R. ([2]), Riccio R. ([5]), Russo G. ([2]), Serlenga V. ([1]), Tarantino S. ([2]), Tragni N. ([1]), Zieke T. ([3]), Bobbio A. ([5]), Capuano P. ([6]), Carlino S. ([5]), Cesca S. ([3]), Emolo A. ([2]), Gallipoli M.R. ([1]), Pilz M. ([3]), Ramatchi M. ([3]), Sens-Schoenfelder C. ([3]), Tillman F. ([3]), Trabattoni A. ([9]), Woith H. ([3])

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([9]) *ESEO - Grand Ecole d'Engegnieurs, France*
([10]) *University of Turin, Italy*

Near-fault observations can provide insights into the physical processes acting at different timescales that generate large earthquakes. The DETECT experiment aims at exploiting very dense seismic networks deployed across a segmented faults system to foster the development of scientific integrated methodologies for monitoring and imaging the faults behavior during the inter-seismic phase. The DETECT experiment, resulting from a joint effort of local Universities, National and International Research Institutes, has been carried out in the Irpinia area (southern Italy), one of the regions in Italy and Europe showing the highest seismic hazard. From August 2021 to July 2022, a constellation of 20 seismic arrays, for a total of 200 seismic stations (20 broad-band sensors and 180 short-periods), was installed over the fault segments responsible for the M_s 6.9, 1980 Irpinia earthquake, the strongest and most destructive seismic event of the last half-century in southern Italy. With this contribution, we aim to present the DETECT experiment, the preliminary results and foster additional cooperation including complementary expertise to further enrich the partnership.

Sensing optical fibers for earthquake source characterization through DAS.

Strumia C. ([1]), Festa G. ([1]), Trabattoni A. ([2]), Scotto di Uccio F. ([1]), Supino M. ([3])

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([2]) *Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, IRD, Géoazur, Nice,*

France
([3]) *Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italia*
Distributed Acoustic Sensing (DAS) is establishing as a powerful approach for earthquake monitoring, turning fiber optic cables in dense spatial arrays able to retrieve almost continuous space-time records of seismic events. While tasks involving time measurements, such as phase picking, can be directly inherited from classical seismology, source characterization requires new methodologies grounded on unconventional quantities as recorded by DAS (strain or strain rate). DAS data show unique azimuthal sensitivity and enhance low-velocity waves trapped in the shallow layering beneath the fiber. Here we discuss and compare two alternative approaches for earthquake source parameter estimation. We either convert DAS data to kinematic quantities or develop a new mathematical formulation for modeling the radiation in the strain domain. Using data from a five-month DAS survey in the Southern Apennines tectonic environment, we characterized source parameters for microseismic events, using a frequency-domain probabilistic approach. We show the capability of DAS technology to depict the characteristic scales of seismic sources and earthquake seismic moment.

● **Semi-automated template matching and machine-learning–based analysis of the Castelsaraceno microearthquake sequence (High Agri Valley, Southern Apennines, Italy).**

Panebianco S. ([1])([2]), Serlenga V. ([1]), Satriano C. ([3]), Cavalcante F. ([1]), Stabile T.A. ([1])
([1]) *Istituto di Metodologie per l'Analisi Ambientale, Consiglio Nazionale delle Ricerche, Tito Scalo, PZ, Italia*
([2]) *Dipartimento di Fisica e Scienze della Terra, Università di Ferrara, Italia*
([3]) *University of Paris, Institut de Phisique du Globe de Paris, Paris, France*
The accurate characterization of microearthquake sequences allows to better understand the physical processes involved in earthquake nucleation and to gain insights on the geometry of fault structures at depth. Standard workflows for the study of earthquake sequences involve manual detection and phase-picking steps, requiring a huge amount of work from expert seismologists, particularly for microseismic events. We show how the investigation of a low-magnitude sequence, occurred in August 2020 close to Castelsaraceno village (southern Apennines) benefited from the application of 4-step semi-automated template matching and machine-learning–based workflow. First, the phase-picking was automatically performed through a deep-learning algorithm on 202 microearthquakes detected between July and October 2020, then an automatic multi-step absolute and relative earthquake location procedure was applied. A total of 72 high-accuracy relocated events clustered in time (7–12 August) and in a narrow range of depths (10–12 km) were recognized as belonging to the sequence. The Ml 2.1 foreshock and the Ml 2.9 mainshock also identified a persistent asperity.

● **Effects of rheology, erosion and temperature on seismicity and tectonics in Agri Valley (Southern Italy).**

Lavecchia A. ([1]), Filippucci M. ([1]), Stabile T. ([2]), Serlenga V. ([2]), Prosser G. ([3]), Tallarico A. ([1])
([1]) *University of Bari "Aldo Moro", Italy*
([2]) *Institute of methodologies for environmental analysis, CNR, Italy*
([3]) *University of Basilicata, Italy*
The Agri Valley is a region where crustal evolution is affected by the interaction of several mechanisms. To model these mechanisms and their evolution, we built up a thermo-rheological numerical model, considering the crust as a visco-plastic body, combining the effects of rheological stratification, inherited weak zones, variations in tectonic regime, surface erosion and fluid presence. Results are in good agreement with the observed topographic

elevation, surface heat flow, strain rate and velocity fields and show that the effect of the crustal compression and extension favors the activations of the Monti della Maddalena and East Agri fault systems, both cross-cutting the allochthonous units and the underlying carbonatic platform. Several seismic networks operate in the Agri Valley including the local network INSIEME managed by the CNR (Potenza, Italy). The 1744 earthquakes, recorded in the period 2002–2019, are clustered in two different areas (Pertusillo Lake and Costa Molina 2 reinjection well). Model results, including fluid presence, retrieve two seismogenic areas where the stress exceeds the plasticity threshold, that are in good agreement with the recorded seismicity.

Crustal structure of seismic gap areas: The case of the Pollino (Italy) and Thessaly (Greece) sequences.

Napolitano F. ([1]), Amoroso O. ([1]), Convertito V. ([2]), De Matteis R. ([3]), De Novellis V. ([2])([4]), Capuano P. ([1])

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Knowledge of the crustal structure of potentially hazardous but long-silent seismic gaps is crucial for seismic hazard mitigation. The occurrence of seismic sequences provides a valuable opportunity to illuminate the properties of the area. We present the results of analyses of the elastic and inelastic properties of two seismic gap areas: the Pollino area (Italy) and the Thessaly area (Greece). The first area was affected by a long-lasting sequence characterised by more than 10000 earthquakes with a predominant swarm-like behaviour and, to a lesser extent, as a mainshock-aftershock sequence following the two main events (ML 4.3 and ML 5.0) that occurred late in the sequence, about two years later. In the second case study, the aftershock sequence, following three medium-intensity events (Mw 6.3, Mw 6.0 and Mw 5.6), dissipated in less than a month during March-April 2021. Seismic tomography and detailed relocation of seismic events were performed for both sequences, with the results then being compared with geological, geophysical and satellite information available for the areas. This work is supported by PRIN-2017 MATISSE project, No. 20177EPPN2, funded by Italian Ministry of Education.

Fault structure and earthquake clustering in Aswan region (Egypt) revealed by high-accuracy earthquake location from 35 years of recorded natural and induced seismicity.

Serlenga V. ([1]), Stabile T.A. ([1]), Fat-Helbary E.R. ([2]), Panebianco S. ([1])([3]), Telesca L. ([1]), El-Ammin E.M. ([2]), Ahmed H. ([2])

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([2]) *National Research Institute of Astronomy and Geophysics, Helwan, Cairo, Egypt*

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Here we study the structure and the triggering mechanisms of faults in Aswan region (South Egypt). The high-resolution locations of 2562 earthquakes (both natural and reservoir induced) collected in the study area from 1982 to 2016 highlight several fault segments, whose kinematics was estimated by focal mechanisms. We observe a time migration towards East and a gradual activation of several faults' strands, which may reveal the fluid migration in the Wadi Kalabsha embayment: the consequent pore-pressure increase would be considered

the main triggering mechanism of the observed seismicity. Earthquake projections onto an E-W cross-section of the study area show a seismic gap localized on the Kalabsha Fault: it may be a locked fault patch, whose spatial extension (about 11 km) could be responsible for an up to $M_{rmw} = 5.9$ earthquake. The clustering analysis on the seismic catalog identifies many earthquake sequences, repeating earthquakes, and seismic swarms. Finally, the *b*-value decrease is correlated with higher seismic moment rates, whereas its increase up to 1.6 is temporally overlapped to a period in which earthquake swarms prevail.

Stress inversion from induced seismicity: The 2013 St. Gallen (Switzerland) case.

Massa B. ([1]), Adinolfi G.M. ([2]), Convertito V. ([3]), De Matteis R. ([1])
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In 2013 a geothermal drilling project started in an area close to the city of St. Gallen (NE Switzerland). Due to the different phases of the project, a sequence of more than 340 earthquakes was induced with a maximum magnitude ML 3.5 and hypocentral depths ranging between 4.1 and 4.6 km b.s.l. We processed these earthquakes to obtain a dataset of Fault Plane Solutions (FPSs) by jointly inverting the long-period spectral-level P/S ratios and the *P*-wave polarities following a Bayesian approach. The resulting FPSs were processed using the Bayesian Right Trihedra Method in order to derive the stress field variations associated to the different well stimulation phases (from July to October 2013). The results derived for the period July to August 2013, highlights an active stress field dominated by a well-constrained NE low-plunging sigma-3 and a corresponding NW low-plunging sigma-1. The corresponding Bishop ratio confirms the stability of the retrieved attitudes. In September 2013, along with a well cleaning procedure, the stress field seems to change drastically. We discuss the impact of the retrieved stress field on the regional tectonic setting.

***P*-wave first motion polarity classification of earthquake waveforms using the CFM convolutional neural network.**

Messuti G. ([1])([3]), Scarpetta S. ([1])([3]), Amoroso O. ([1]), Napolitano F. ([1]), Falanga M. ([2]), Capuano P. ([1])
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We present the Convolutional First Motion (CFM) network, a Deep Convolutional Neural Network (DCNN) used to classify seismic traces based on first motion polarities of *P*-waves. The network, trained on $\sim$ 140000 time windows centered on *P*-wave arrival times of waveforms belonging to the INSTANCE catalogue, shows high accuracy levels (*i.e.*, 97.4% and 96.2%) when tested on two independent test sets, high reliability and great generalization ability. Further testing showed that if we give the network waveforms with uncertain arrival times, it acquires robustness to this type of noise, still showing high-level of performance. We infer that the CFM network would be suitable in succession to automatic techniques that derive *P*-wave arrival times, for example techniques in which deep learning is used, in order to cover the entire data processing phase with machine learning. Given the incredible ability of DCNNs to model and process large volumes of data and their remarkable performance, it is reasonable to assume that deep learning will soon become the norm even in the context of first-motion.

Aula F7 - Giovanna Mayr **ore 09:00 – 13:30**

Sezione V
Biofisica e fisica medica
Presiede: Ciarocchi E. (Università di Pisa e INFN, Sezione di Pisa)

Relazioni su invito

▲ **Dall'"equipment compliance" all'"optimal use of equipment" in tomografia computerizzata: un gioco di equilibrio tra qualità di immagine e dose.**
Trianni A., Ravanelli D., Orsingher L.
Azienda Provinciale per i Servizi Sanitari, Provincia Autonoma di Trento
Dato l'importante aumento del contributo della tomografia computerizzata alla dose collettiva, un'attenzione maggiore va dedicata al processo di ottimizzazione per rispondere ad uno specifico quesito clinico mantenendo la dose al paziente più bassa possibile. Le quantità fisiche legate alla dose sono definite in modo rigoroso con delle correzioni che tengono conto della specificità del paziente. La qualità fisica dell'immagine può essere valutata tramite metriche tradizionali basate sulla teoria dei segnali di sistemi lineari e invarianti. Tali metriche sono adeguate per la caratterizzazione del sistema di immagine, ma non applicabili nel caso di algoritmi iterativi di ricostruzione, con immagini non lineari e non stazionarie, dove si deve cambiare il paradigma verso metriche "evolute". La qualità fisica non rende inoltre appieno delle ricadute in termini di qualità clinica delle immagini. A questo scopo, è necessario utilizzare metriche "task-based performance", in grado di considerare le necessità reali dei radiologi ed evitare il rischio di *undetected pathology*. Sono percorribili due metodiche di analisi *task-based*: la prima basata sulla valutazione diretta degli osservatori (*human observer studies*), la seconda che prevede l'utilizzo di modelli matematici che mimano la percezione umana da utilizzare come "surrogati" dell'osservatore umano (*model observer studies*).

▲ **Tomografia computerizzata: dalla ricerca alla pratica clinica, ai tempi del photon counting.**
Panetta D. ([1])([2]), Rosso V. ([2])([3]), Cademartiri F. ([4])
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La rivelazione diretta a conteggio di singolo fotone (PCD), derivata dalla ricerca in fisica delle particelle, è già da decenni utilizzata nell'imaging diagnostico nucleare. Solo molto recentemente, questa tecnologia è stata applicata con successo all'imaging TC di livello clinico, a causa dell'elevato count-rate richiesto per questa applicazione ($> 10^8$ $s^{-1}mm^{-2}$) e di limitazioni inerenti alla condivisione di carica tra i pixel e alla fluorescenza. I vantaggi offerti dal PCD rispetto alla convenzionale integrazione di carica vanno dalla riduzione del blurring da scintillazione, alla riduzione di artefatti, fino alla creazione di mappe elementali mediante sottrazione sul K-edge. Saranno presentate le più recenti evidenze sui vantaggi del PCD in TC sia preclinica che clinica, e discussi alcuni risultati ottenuti nell'ambito della Collaborazione MEDIPIX4 del CERN, che vede l'INFN tra i partner. Sarà anche discusso lo stato dell'arte e le nuove prospettive in ambito di ricostruzione delle immagini per imaging spettrale, nonché le direzioni della ricerca su mezzi di contrasto alternativi allo iodio, con riferimento alla ricerca preclinica cardiovascolare.

▲ **Reti complesse e intelligenza artificiale in fisica medica.**

Bellotti R.
Università degli Studi di Bari Aldo Moro e Istituto Nazionale di Fisica Nucleare

La complessità dei dati prodotti oggigiorno nei settori della biofisica e della fisica medica pone problemi interpretativi di non semplice soluzione. La crescita imponente dei dati disponibili, quali le immagini diagnostiche ad alta risoluzione spaziale e temporale, i dati genomici e i dati ambientali, insieme ad una buona accessibilità a sistemi per il calcolo scientifico avanzato, hanno reso possibile studiare questi sistemi del dominio delle scienze della vita, dal DNA al cervello, con approcci "data driven". In questo seminario si descriveranno alcune metodologie allo stato dell'arte, in particolare la *complex network analysis* e la *explainable artificial intelligence*, particolarmente utili per lo studio di tali sistemi.

Comunicazioni

● **Comparazione di metodi di spiegabilità della AI in fisica medica: diagnosi della polmonite da immagini X-ray.**

Marini L., Fantini A., Quarta A.
University of Pisa

In questo lavoro presentiamo un approccio basato su deep-learning (DL) per l'identificazione della polmonite mediante l'analisi di immagini X-ray. Il dataset utilizzato contiene 5863 immagini radiografiche del torace suddivise in 2 categorie (polmonite/normale) e sono state raccolte e rese disponibili pubblicamente dal Guangzhou Women and Children's Medical Center (China). In particolare, è stato implementato un modello DL pre-addestrato (VGG16) in grado di eseguire la classificazione automatica dei pazienti. Inoltre, l'impiego di due diversi metodi di spiegabilità (explainability) del modello, LIME e Grad-CAM, ha consentito l'interpretazione dei risultati. Entrambi i metodi permettono la visualizzazione di una mappa in grado di evidenziare il contributo di ciascuna regione e/o pixel delle immagini al processo decisionale della rete. Il modello raggiunge un'accuratezza dell'81% e un'area sotto la curva ROC del 93%. Sia LIME che Grad-CAM mostrano come il modello DL identifichi un certo pattern ricorrente associabile alla polmonite.

● **Multi-messenger radiomics of lung cancer: preliminary results for radiomic features stability among different imaging modalities and extraction software.**

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Currently, lung Magnetic Resonance Imaging (MRI) is not able to reach Computed Tomography (CT) performances. Being a non-invasive technique, different tools are nowadays

employed to improve lung MRI quality. On the other hand, remarkably radiomics has revealed a possibly powerful data analysis method transversal to all Imaging techniques, as it allows to extract quantitative data. In this context, our goals are to investigate the statistical reliability of CT and MRI lung cancer radiomics features and the agreement between two freeware radiomics software, Pyradiomics and LIFEx. This study concerned CT and MRI images from 26 patients, analyzed by using 3 different voxels resampling and 66 selected features. Pyradiomics-LIFEx correlation for each imaging technique, and CT-MRI correlation for each radiomics platform, were investigated. Good/excellent Interclass Correlation Coefficient (ICC) reliability was reached by the following features percentage: MRI nearly 90% and CT 85% considering all the resampling, and less than 15% for both radiomics software. ICC reliability of Pyradiomics and LIFEx features was excellent for at least 45% of features.

Reducing interobserver variability in radiomics studies through ComBat harmonization.

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In radiomics, tumour segmentation is usually performed manually by radiation oncologists, but different operators often produce variable results. This variability may compromise statistical analysis and modelling. The usage of ComBat harmonization to reduce the Interobserver Features Variability (IFV) was investigated on the NSCLC-Radiomics-Interobserver1 public dataset which includes repeated blinded manual delineations of the GTV by five different radiation oncologists (3 trainees and 2 experienced). Segmentations were performed either manual or with an autosegmentation tool followed with manual editing. 593 radiomic features (shape, first order, GLRLM, GLSZM, and GLDM) were extracted from original and wavelet images for each GTV-1 structure, segmentation method, and radiologist types. A Mann-Whitney U-test was performed for all possible pairs of radiologists before and after ComBat. Among all, radiomic features extracted from wavelet images showed a greater IFV. ComBat was effective in reducing IFV for both manual contouring (86%) and autosegmentation with manual adjustment (80%). When applied correctly, ComBat could reduce the IFV and enable multicenter studies.

Complex network and artificial intelligence combined approach to investigate autism spectrum disorder through gene expression data.

Lacalamita A. ([1])([2]), Monaco A. ([1])([2]), Amoroso N. ([3]), Bellantuono L. ([2])([4]), Fania A. ([1])([2]), Pantaleo E. ([1])([2]), Tangaro S. ([2])([5]), Bellotti R. ([1])([2])

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Autism spectrum disorder (ASD) is a complex neurodevelopmental disorder where only 20% of cases can be explained by known genetic mutations. Recent studies have identified a

relationship between gene expressions and ASD through brain transcriptome analysis. In our study we analyzed a publicly available dataset of gene expression from 94 individuals (51 healthy and 43 autistic) to identify gene communities most related to ASD. Through a data-driven approach based on complex networks, we have grouped thousands of genes into small stable communities by exploiting the spin-glass algorithm inspired by the model of Nobel Prize winner Giorgio Parisi. The Boruta algorithm, a wrapper method, was then applied to select the most discriminating genes within each community. Finally, Random Forest (RF), a machine learning algorithm, was used to classify the 29 communities found via complex network approach; RF provides a classification accuracy ranging from 70.86% to 77.61%. Our results suggest that using gene expression and artificial intelligence may help identify new ASD-related biomarkers, but further studies are needed to validate these gene communities biologically and statistically.

One health paradigm higlights the connection between O_3 and NO_2 pollutants and Alzheimer's disease.

Fania A. ([1])([2]), Monaco A. ([1])([2]), Amoroso N. ([2])([3]), Bellantuono L. ([2])([4]), Cazzolla Gatti R. ([5]), Firza N. ([6])([7]), Lacalamita A. ([1])([2]), Pantaleo E. ([1])([2]), Tangaro S. ([2])([8]), Velichevskaya A. ([1])

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Alzheimer's disease (AD) is a prevalent form of dementia that affects millions of people worldwide. Despite the lack of a cure and the difficulty in diagnosing the disease early on, it is crucial to study the physiology and pathogenesis of AD to identify risk factors that may contribute to its onset. While AD is a complex disease with multiple causative factors, there is growing evidence that environmental pollution plays a significant role in its development. To investigate this relationship further, we developed an Artificial Intelligence model to predict AD mortality in Italian provinces over a five-year period using publicly available data on pollution, health, society, and economy. By employing methods based on eXplainable Artificial Intelligence (XAI), we determined that air pollution, particularly O_3 and NO_2, had the greatest impact on AD mortality. These findings provide insight into the etiology of Alzheimer's disease and highlight the need for further research on the link between environmental pollution and the disease. Also, the dataset used in this study has been published. Long-term, spatially detailed, readily available data can be in fact beneficial for both health monitoring and research on new treatments, drugs, and innovative methodologies for early dementia diagnosis.

Development and comparison of spectral X-ray imaging systems using synchrotron radiation.

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Spectral K-edge X-ray imaging takes advantage of the sharp rise in the attenuation coefficient of high-Z elements at their K-edge. This technique requires the acquisition of images at multiple energies below and above the target K-edges to provide separate and quantifiable density maps for each element. In this contribution, the performances of two spectral imaging systems, implemented at a synchrotron facility, are assessed and compared. The first system is diffraction-based, relying on an energy-dispersive bent-Laue crystal which produces a continuous energy spectrum. The second one includes an energy-resolved X-ray photon counting detector, which provides spectral information by implementing two energy thresholds. Samples containing contrast elements relevant for biomedical imaging in different dilutions were used to evaluate the sensitivity of both systems. All images were acquired in tomographic mode. Sensitivity to very small concentrations (0.5 mg/ml) was reached. Moreover, simultaneous tomographic imaging of the K-edges of iodine, xenon, and barium, owing to the achievement of a large energy bandwidth over a large field of view is being demonstrated for the first time.

Energetic characterization of Timepix4 detector for spectral imaging.

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Timepix4 is the novel, large-area, hybrid pixelated detector developed at CERN by the Medipix4 Collaboration, made up of various international partners, including the INFN. The detection system consists of an innovative readout matrix of 448×512 pixels connected by bump-bonding to a semiconductor material sensor with square pixels of 55 um pitch. Two operating modes are available, the frame-based and the data-driven mode. In the latter, the Timepix4 can measure the signal's Time of Arrival (ToA) and the signal's time duration through Time over Threshold (ToT) measurements. This makes it possible to obtain the energy released by the incident photons in each pixel. The maximum rate of events the device readout can process in data-driven mode is 3.6 Mhit/mm^2/s. These features enable the Timepix4 to resolve individual particles incident on the sensor and measure their energy, making it an excellent detector for accurate spectral imaging. In this work, we present the results of the energy characterization of one of these devices, equipped with a 300 um thick Si sensor, operating in data-driven mode.

Monte Carlo study of an innovative CBCT oscillating scanning geometry for image quality improvement.

Mauriello P., Sarno A.
Università degli Studi di Napoli-Federico II e INFN Sezione di Napoli

Cone-Beam Computed Tomography (CBCT) has its main limitations in the abundance of scatter radiation and the conic beam confined on a circular trajectory which affect precision and accuracy in quantitative analysis. This work aims at investigating, by means of a validated Monte Carlo code, an innovative geometry with collimated beam and oscillating scanning geometry. The code was based on Geant4 simulation toolkit and GGEMS platform for computation time acceleration by employing GPU architecture. Simulations showed that the SPR reduced of 13.25% passing from a full field irradiation to a 3 cm height collimated beam with a phantom of 60 mm thickness in projected images. The same reduction of the field of view increased CNR between two simulated inserts made of adipose and glandular tissue of 50% and improved microcalcification visibility. Moreover, we developed a digital phantom for evaluating the accuracy and precision of HU evaluations in 3D images and image conspicuity, largely affected by cone-artifacts in conventional CBCT. Such a phantom is constituted of some PMMA slabs sandwiched between thin air layers and contains inclusions made of water, PC, PE and PVC.

Innovative cone beam computed tomography orbit toward quantitative imaging.

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This work aims at investigating an innovative cone beam CT (CBCT) scanning geometry (ExoCT) for reduction of detected scatter and cone artifacts for improvement of accuracy and precision in quantitative evaluations. A CBCT scanner prototype was upgraded by permitting an oscillating trajectory and a tuneable beam collimation with the intent of reducing scatter and cone-related artifacts. In experimental studies on wax handmade phantom embodying different material inserts we found out that the ExoCT permits to improve accuracy in attenuation coefficients estimates up to 15% with respect to CBCT. A test on a Defrise phantom, with air gaps sandwiched between plastic discs showed that conspicuity of reconstructed images for remote portion of the FOV is preserved in ExoCT, with the visibility of quoted air gaps reduced in CBCT for large cone angles. Normalised noise power spectrum resulted 35% lower in ExoCT, this is mainly due to the minor amount of the detected scatter. Comparison between image quality of ExoCT and conventional CBCT showed that, in the first one, the reduction of cupping artifacts led to increase the accuracy in quantitative analysis.

Hp(3) vs. TLD-100 per dosimetria al cristallino in procedure di radiologia interventistica.

Manna F. ([1])([2]), De Nardellis G. ([1]), Carmosino P.A. ([3]), Ambrosino F. ([1])([4]), Caruso U. ([3]), Correra M. ([3]), Fiore F. ([3]), La Verde G. ([1])([4]), Tarotto L. ([3]), Pugliese M. ([1])([4])
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Il D.Lgs 101/2020 ha abbassato il limite di dose equivalente al cristallino da 150 a 20 mSv annui per ridurre il rischio di cataratta radio-indotta nei lavoratori esposti. Una così dra-

stica riduzione evidenzia la necessità di adottare metodi accurati di valutazione dosimetrica. L'estrema diffusione di procedure guidate da immagini fa sì che tutto lo staff sanitario nelle radiologie interventistiche sia tra le categorie di lavoratori maggiormente esposti. Lo scopo del lavoro è stato quello di utilizzare dosimetri TLD-100 e Hp(3) opportunamente calibrati per effettuare valutazioni di dose al cristallino mediante esposizioni controllate su un fantoccio tessuto-equivalente che simulasse la testa del primo operatore. Le misure sono state effettuate presso la S.C. di Radiologia Interventistica dell'Istituto Nazionale Tumori Pascale di Napoli mediante il sistema angiografico con arco a C Artis Zeego Eco della Siemens e lavorando con tensioni del tubo comprese tra i 63 e i 74 kVp per simulare procedure standard di drenaggio biliare.

Optimizing multilayered radiation shielding structures using genetic algorithms.

Cordella F., Pacella D., Panza F., Ciotti M., De Leo V., Claps G.
ENEA Frascati

Radiation shielding is critical in various fields, such as space exploration, medical devices, and nuclear facilities. The optimization of radiation shielding structures poses a complex challenge due to the multitude of materials and configurations available. This communication introduces a genetic algorithm-based approach for optimizing multilayered shielding structures, aiming to minimize the total ionizing dose while considering the number of layers and the total thickness of the materials used. The impinging spectrum is composed of neutrons with a wide energy spectrum up to 14 MeV and the optimization process utilizes Python and Geant4. Despite the challenges of parameter tuning, genetic algorithms offer an efficient and robust approach to solving optimization problems in large and complex search spaces. They can be a powerful tool for solving many optimization problems, including optimizing radiation shielding materials and configurations in various applications. After obtaining the Geant4 and Python results, the best, median, and worst TID values will be compared with the three Monte Carlo codes: Geant4, Fluka, and MCNP codes.

Aula F5 - Hildred Blewett **ore 09:00 – 13:30**

Sezione VI

Fisica applicata, acceleratori e beni culturali

Presiede: Caliri C. (ISPC-CNR e INFN, Laboratori nazionali del Sud, Catania)

Relazioni su invito

▲ **Fixed and mobile instrumentation for cultural heritage diagnostics.**

Ruberto C.

Dipartimento di Fisica e Astronomia, Università degli Studi di Firenze e Istituto Nazionale di Fisica Nucleare, INFN, Sezione di Firenze

Diagnostics for Cultural Heritage (CH) is a well-established research field, as material analysis can provide information useful for the study of manufacturing techniques, dating, provenance, authenticity and conservation status of artworks. Usually, CH diagnostics require non-invasive and non-destructive analysis with high sensitivity. The national/international framework highlights that Ion-Beam Analysis (IBA) and X-Ray Fluorescence (XRF) spectroscopy are very powerful techniques. A feature crucial for CH applications is the possibility to perform *in situ* measurements, without moving the artworks to the scientific laboratories. While this task can be easily accomplished with XRF portable instruments, *e.g.*, at museums, at present no mobile IBA systems are available. To overcome the risk of misleading/ambiguous information obtained through single spot measurement, significant effort has been dedicated by the scientific community to develop imaging techniques, using scanning mode acquisition systems. To highlight the strengths of these techniques all these points will be discussed providing examples from CH applications and recent updates will be presented.

▲ **Deep learning models for MA-XRF imaging of paintings.**

Preisler Z. ([1]), Busacca A. ([1]), Andolina R. ([1]), Caliri C. ([1])([2]), Miliani C. ([1]), Romano F.P. ([1])([2])

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The current advancements of noninvasive imaging methods applied to the study and conservation of cultural heritage have driven a rapid development of novel computational methods. Macro x-ray fluorescence (MA-XRF) is a well-established technique used for the investigation of paintings. However, MA-XRF generates large datasets that can be challenging to analyze. In the following, we employ machine learning approaches for the analysis as they can identify nontrivial dependences promising a more comprehensive interrogation. We have built a deep learning network trained on a synthetic dataset allowing fast and accurate analysis of the XRF spectra circumventing typical drawbacks of the classical deconvolutional approach. The synthetic XRF spectra are generated using Monte Carlo simulations and tuned for our MA-XRF setup. The presented approach yields high-quality results in terms of analysis of MA-XRF scans. In particular, we recover the absolute intensities of elemental lines and we show the improvements of our approach in comparison with the output of the classical analysis. We discuss the results of this methodology applied to the analysis of both historical and modern paintings.

Comunicazioni

Innovative methodologies in the stable isotope analysis for cultural heritage.
Lubritto C. ([1])([3]), Di Cicco M.R. ([1])([3]), Mantile N. ([1])([3]), Altieri S. ([1])([3]), Cocozza C. ([1])([3]), Soncin S. ([2])([3]), Formichella G. ([2])([3]), Farese M. ([2])([3]), Panella S. ([2])([3]), Tafuri M. ([2])([3])
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In the last decades there has been a growing interest about archaeometric researches upon osteoarcheological remains as a source of information to investigate past lifestyles. Stable isotope analysis of collagen, the organic component of the bone, allows us to gather a wealth of information ranging from paleo-diet, climate changes, social status, exploitation of local resources, migrations, weaning age, breeding and farming practices of ancient populations In this communication we present some recent methodologies introduced in these fields such as: i) incremental dentine isotopic methodologies; ii) Bayesian modelling tool; iii) carbon and nitrogen isotope analysis of amino acids (compound-specific isotope analysis of amino acids CSIA-AA). These approaches were tested on sample coming from different sites (Pompeii Ostia, Herculaneum) to investigate the life of ancient community in some of the central economic hubs of the Roman Empire.

Physics in archaeometry and cultural heritage: An overview of the activities at the Physics Department, University of Torino, and INFN, Torino division.
Re A., Lo Giudice A.
Department of Physics, University of Turin, Turin, Italy e National Institute of Nuclear Physics, Turin Division, Turin, Italy
It has been 15 years since the start of activities in physics applied to archaeometry and cultural heritage at the Physics Department of the University of Turin and INFN, Turin division. The important impact of these activities on civil society can be seen in the countless collaborations established not only with national and international academic and research institutions, but also with museums, superintendencies, conservation and restoration centres, private companies, etc. This leads to an important visibility of the activities of applied physicists, which is also useful for a greater appreciation of basic research. In Turin, the main activities are related to the use of X-ray beams, protons and neutrons for the analysis of materials and objects of archaeological and historical-artistic interest. The main answers that can be provided to historians, archaeologists, restorers and conservators concern: the state of conservation, to define the best restoration and preventive conservation strategies; information on the types of materials used, the construction techniques, the provenance of raw materials, etc.

Modellazione dinamica ad elementi finiti applicata ai beni culturali: Il caso delle colonne classiche greche.
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La modellazione ad elementi finiti (FEM), finalizzata al calcolo della risposta dinamica di oggetti attraverso la loro suddivisione in un numero variabile di elementi di forma geometrica elementare, è applicabile in differenti ambiti, tra cui i beni culturali. In tal senso, ad esempio, la modellazione di colonne di antichi templi di epoca classica risulta di grande interesse, poiché, sebbene la loro struttura sia apparentemente semplice, il loro comportamento dinamico è altamente non lineare, specialmente nel caso di eventi sismici distruttivi, dando luogo

al fenomeno di traslazione e rotazione dei conci, noto con il nome di rocking. Il presente contributo illustra la simulazione numerico-grafica di un set di colonne classiche greche, il cui comportamento dinamico è stato in precedenza misurato e riportato in letteratura. I risultati ottenuti permetteranno di sviluppare modelli più complessi di strutture, quali interi templi. Tale implementazione, poi, sarà utilizzabile, integrata e confrontata con misure *in situ*, al fine di fornire un supporto per il monitoraggio dello stato di salute ed un supporto per la pianificazione di strategie di gestione di beni culturali architettonici.

La spettroscopia infrarossa con luce di sincrotrone applicata ai beni culturali: Applicazioni e sviluppi.

Romani M., Pronti L., Cestelli Guidi M
INFN, Laboratori Nazionali di Frascati, Frascati, Italia

Presso la beamline SINBAD IR (Synchrotron Infrared Beamline At Dafne) è possibile utilizzare la luce di sincrotrone, estratta da uno dei magneti curvanti dell'acceleratore DAFNE dei Laboratori Nazionali di Frascati dell'INFN, per esperimenti di spettroscopia ed imaging per la caratterizzazione dei materiali nell'infrarosso. Lo spettro della radiazione si estende dal THz fino al NIR ed è possibile lavorare in diverse modalità d'acquisizione. Nel campo dei Beni Culturali, questa tecnica è sempre più utilizzata per misurare la risposta spettrale dei materiali nell'infrarosso specialmente nelle fasi preliminari al restauro, consentendo di ottenere informazioni utili per la scelta della migliore metodologia operativa. L'elevata precisione ed accuratezza, unita alla sua natura non distruttiva e alla possibilità di lavorare su quantità minime di campione la rende la tecnica ideale per la caratterizzazione chimica e mineralogica dei materiali costituenti le opere d'arte. In questa comunicazione vengono presentate alcune delle applicazioni realizzate dal laboratorio di luce di sincrotrone su materiali pittorici e archeologici evidenziando i vantaggi della tecnica e gli sviluppi futuri.

Studio di monumenti di interesse storico ed archeologico mediante approccio fisico-ambientale nel contesto evolutivo storico-culturale.

Barone F. ([1]), Casazza M. ([1]), Romano R. ([2])
([1]) *Dipartimento di Medicina, Chirurgia e Odontoiatria "Scuola Medica Salernitana", Università di Salerno, Italia*
([2]) *Dipartimento di Farmacia, Università di Salerno, Italia*

La caratterizzazione di monumenti di interesse storico ed archeologico richiede lo sviluppo e l'applicazione di metodi e tecniche di analisi atte a descrivere il comportamento dinamico del monumento in relazione alla struttura ed alle sue interazioni con il sito a cui è solidale (sito-struttura) e con i forzamenti ambientali (struttura-ambiente). Una possibile soluzione è stata sviluppata integrando diverse tipologie di sensori in un'unica piattaforma di monitoraggio multi-parametrico, che, integrata con tecniche di analisi dati implementate *ad hoc*, permette di ottenere una rappresentazione unitaria della dinamica dei monumenti. Tale soluzione è stata applicata, ad esempio, al monitoraggio ed alla caratterizzazione vibro-acustica di oggetti e luoghi, partendo dagli strumenti musicali fino agli spazi performativi e a siti di rilevanza storico-archeologica. Saranno presentati i risultati ottenuti con questo approccio innovativo, utilizzabili anche a supporto dell'interpretazione delle evidenze archeologiche e delle fonti documentali disponibili nonché a supporto della caratterizzazione dell'identità del luogo quale dimensione immateriale del patrimonio culturale e paesaggistico.

Test di autenticità TL: *Best practices* e procedure sperimentali.

Paladini G., Peri B., Politi G., Stella G., Gueli A.M.
Dipartimento di Fisica e Astronomia "Ettore Majorana", Università degli Studi di Catania

Viene presentato uno studio metodologico avente come obiettivo l'individuazione di una procedura sperimentale tale da garantire la realizzazione di test di autenticità di manufatti

di ceramica e di terracotta con il metodo della termoluminescenza (TL) di elevata affidabilità. In particolare, viene presentato il confronto tra i dati ottenuti con differenti metodologie sia di preparazione del campione sia di misura ed elaborazione dei segnali di luminescenza. La preparazione dei campioni da sottoporre a misura viene effettuata sia con la metodologia standard per i test di autenticità, che prevede l'utilizzo di un trapano a bassa velocità, sia con la procedura di routine per la datazione TL che prevede il prelevamento di una porzione del campione da ridurre in polvere in un mortaio di agata. L'applicazione della termografia consente di monitorare la temperatura di prelevamento durante la foratura del reperto. I segnali di luminescenza sono ottenuti sia con la tecnica dell'*added dose* che della *regeneration* per tutti i campioni analizzati. L'influenza delle metodologie viene valutata considerando soprattutto l'effetto sulla valutazione della compatibilità dell'età presunta.

Computed tomography and first steps to bring ancient wood wind instruments back to life.

Tansella F. ([1])([2]), Ricchiardi G. ([3]), Re A. ([1])([2]), Vigorelli L. ([1])([2])([4]), Bonizzoni L. ([5]), Grassini S. ([6]), Staropoli M. ([7]), Lo Giudice A. ([1])([2])
([1]) *Physics Institute, Turin University, Italy*
([2]) *INFN, Turin Section, Italy*
([3]) *Chemistry Institute, Turin University, Italy*
([4]) *Electronics and Telecommunications Department, Polytechnic University of Turin, Italy*
([5]) *Physics Institute, Milan University, Italy*
([6]) *Department of Applied Science and Technology, Polytechnic University of Turin, Italy*
([7]) *Conservatory of Music "G. Tartini", Trieste, Italy*

Computed Tomography (CT) is an analysis technique that allows a three-dimensional reading of the internal structure of the analysed object, allowing a real measurement of internal structural elements, fractures or peculiarities. For analysis of small samples or in cases where particularly high spatial resolution is required, a micro-CT system can be used. Microtomography allows to obtain images of considerably higher quality and resolution than CT, such as to make it relatively competitive with other more invasive techniques, such as the SEM. This technique was used to study a late Eighteenth-Century Transverse Flute, to study its internal structure and obtain the information necessary to create a playable reproduction. The musical instruments in the museum collections were designed as functional objects, designed to communicate and impress. To preserve and transmit the material characteristics of such objects, the intangible ones are often lost. in fact, the use of woodwind instruments is particularly problematic, as, during the execution, there are considerable changes in humidity and temperature inside the barrel of the instrument with consequent risks in terms of conservation.

Datazione di malte storiche da frazioni di carbonato di calcio.

Galvagno R., Reitano R., Stella G., Gueli A.M.
Dipartimento di Fisica e Astronomia "Ettore Majorana", Università degli Studi di Catania, Catania, Italy

L'applicazione della luminescenza otticamente stimolata (OSL) a malte storiche rappresenta un importante passo avanti in campo archeometrico in quanto permette di superare la problematica legata alla datazione di edifici storici con la termoluminescenza (TL). La tecnica si basa sull'ipotesi che l'evento azzerante coincida con la posa della malta e, quindi, con l'edificazione. Ma visto che nel passato i laterizi venivano spesso riutilizzati, la tecnica in realtà restituisce la data di manifattura di questi ultimi. La metodologia attuale utilizza come dosimetro il quarzo presente nella malta. Esso rappresenta il dosimetro di elezione grazie alla presenza di trappole easy-to-bleach e alla risposta lineare a basse dosi. Fenomeni di bleaching parziale riducono, però, la precisione dei risultati. Il nostro studio si basa sull'ipotesi

che un contributo importante possa essere dato dai segnali di luminescenza del carbonato di calcio, che si forma durante la manifattura, per il quale il bleaching totale è assicurato. Verranno presentati i risultati ottenuti su frazioni di carbonati estratti da malte storiche, di varia tipologia, preparati e misurati con procedure differenti.

Application of Terahertz Continuous Wave (THz-CW) spectroscopy for the quantitative identification of Cultural Heritage materials.

Moffa C. ([1]), Merola C. ([2]), Piamonte Magboo F.Jr. ([1]), Curcio A. ([3]), Palumbo L. ([1]), Felici A.C. ([1]), Petrarca M. ([1])

([1]) *Department of Basic and Applied Sciences for Engineering SBAI, Sapienza, University of Rome*

([2]) *Department of Environmental Biology DBA, Sapienza, University of Rome*

([3]) *National Laboratory of Frascati - LNF-INFN, Frascati, RM*

Techniques based on terahertz (THz) radiation allow non-destructive and non-invasive analysis, making them highly interesting for Cultural Heritage (CH). Materials used for CH objects (e.g., binders and supports) are often transparent in this spectral region. Thus, it is possible to observe specific fingerprints for pigments allowing for their selective identification on artefacts which can provide insightful information like material composition, conservation state, and potential deterioration factors. In this work we obtained the optical parameters (absorption coefficient and refractive index) for pigments and dyes with terahertz continuous wave spectroscopy (THz-CW) with a compact and portable experimental set-up with high-frequency resolution (in the order of 10 MHz) in the range 0.1-3 THz. Moreover, we also investigated some historically used mixtures. The results showed that it was possible to identify and quantify pure compounds in mixtures thanks to the high selectivity offered by THz-CW spectroscopy. The outcome of this work shows that THz-CW spectroscopy can be considered an innovative and extremely promising technique that offers significant prospects as a diagnostic method for CH.

Aula F2 - Ginestra Giovene Amaldi **ore 09:00 – 13:30**

Sezione VII
Didattica e storia della fisica
Presiede: Robotti N. (Università di Genova)

Relazioni su invito

▲ **From cosmic rays to astro-particles: building a culture of messengers from outer space.**
Bonolis L.
Max Planck Institute for the History of Science, Berlin, Germany
Drawing on a series of key cases and prominent figures, it will be illustrated how traditional cosmic ray studies evolved in the second half of the twentieth century into a multifaceted culture by opening new windows on the universe and unprecedented vistas of inquiry through the development of new techniques capable of picking up the message carried by previously inaccessible cosmic messengers.

▲ **The development of the concept of exchange forces in the 1930s: close encounters between Europe and Japan and the birth of nuclear theory.**
Naddeo A. ([1]), Di Mauro M. ([2])
([1]) *INFN, Sezione di Napoli, Napoli, Italia*
([2]) *Dipartimento di Fisica, Università di Trento, Povo, Trento, Italia*
The concept of exchange interactions has been introduced in the second half of 1920s in connection with the quantum mechanical description of systems of identical particles. It made its first appearance in the domain of nuclear physics only in 1932, after the discovery of the neutron, then shifted to quantum field theory, paving the way to the understanding of fundamental forces as mediated by virtual particle exchange. Intermediate steps of this development are the Heisenberg theory of nuclear structure, Majorana's further formulation of nuclear exchange forces and Fermi's theory of beta-decay. H. Yukawa as well as S. Tomonaga, who already had been exposed to the principles of the new quantum mechanics by taking part in a cycle of lectures given by Heisenberg and Dirac in Japan in 1929, were strongly influenced by these works. Within a couple of years Yukawa conceived his crucial idea of a mediating virtual meson, while Tomonaga was working on the range of proton-neutron interactions. In this contribution, the role played by Japanese physicists in building the modern understanding of fundamental forces in the 1930s is carefully analysed and related to previous key results.

▲ **The man who saw ghosts: Feynman's work on classical and quantum gravity.**
Di Mauro M. ([1]), Naddeo A. ([2])
([1]) *Dipartimento di Fisica, Università di Trento, Povo, TN, Italia*
([2]) *INFN, Sezione di Napoli, Napoli, Italia*
Feynman's work on gravitation is reconstructed and contextualized, starting from the 1957 Chapel Hill conference, where he proposed his famous sticky-bead argument for the existence of gravitational waves. From the beginning, Feynman adopted a field theoretical approach to general relativity, in which Einstein's equations and curved geometry follow from the properties of Lorentzian quantum field theory for a massless spin-2 field. A more refined version was sketched in 1961 in a letter to Victor Weisskopf and applied to the computation

of the power radiated as gravitational radiation by a binary star system. These ideas were fully developed in the famous lectures on gravitation delivered at Caltech in 1962-63 and in a few published papers, where some field theoretical tools "soon found to be of general interest" such as ghosts and the tree theorem, were introduced, with the aim of formulating a quantum theory of gravity. Further original pieces of Feynman's work on gravity are present in a set of unpublished lectures delivered at the Hughes Aircraft Company in 1966-67, devoted mainly to astrophysics. Finally, Feynman's approach is compared with contemporary and subsequent work.

Comunicazioni

Free-energy calculations in soft and hard matter: From Hamiltonian thermodynamic integration to early applications of umbrella sampling.

Macuglia D.
Peking University, Beijing, China

The development of methods to calculate free energy has represented a major challenge for generations of scientists engaged in both analytical approaches and computer simulations. This communication aims to outline an analysis of the most significant works, together with a chronology and a systematized collection of primary sources useful for further historical insights. The period covered begins with analytical studies by John Kirkwood in 1935 to the publication of the first technical review on free-energy calculations that followed the 97th course of the International School of Physics "Enrico Fermi" organized in 1985 in Varenna, Italy, on *Molecular-Dynamics Simulation of Statistical-Mechanical Systems*. The emphasis of this study will be on simulative techniques and the main difficulties faced by scientists engaged in molecular simulations. Despite some references in texts aimed primarily at natural-science readers, the history of free-energy computation still lacks adequate systematization. This communication aims at addressing this issue and suggests some ways to improve historiographical research.

Se questo è un prof: l'incredibile avventura umana e scientifica di Bernardo Dessau, fisico, scienziato, maestro, tra i marosi del secolo breve.

Carlotti G.
Dipartimento di Fisica e Geologia, Università di Perugia, Perugia, Italia

Ci si propone di sollevare il velo di oblio che per troppo tempo ha coperto la vicenda di Bernardo Dessau, scienziato di origine tedesca e tradizione ebraica, che visse in Italia tra la fine '800 e metà '900. Dalla laurea con Kundt a Strasburgo nel 1886 al lavoro di ricerca sulle onde elettromagnetiche e sulla telegrafia senza filo, come assistente del prof. Augusto Righi, presso l'Università di Bologna per un quindicennio. Fu tra i primi soci della SIF. Poi l'incarico di docenza a Perugia nel 1904, la sua fama di scienziato e divulgatore, il suo apporto allo sviluppo della fisica italiana e del CNR, la sua capacità di grande didatta, attento sia agli studenti che al grande pubblico, le strabilianti scoperte della nuova fisica. Accanto ai successi scientifici, egli dovette subire peripezie e discriminazioni a causa della sua origine tedesca e del suo essere ebreo, sperimentando sulla propria pelle, e su quella dei suoi familiari, la tragicità degli eventi storico-sociali che sconvolsero il "secolo breve". Entrambi questi aspetti saranno approfonditi, provando a rendere un po' di giustizia ad uno scienziato largamente sottovalutato, che morì solo e dimenticato nel 1949.

Contaminazione da camera a nebbia - un'esperienza a Roma Tre.

De Angelis I. ([1])([2]), Budano A. ([2])
([1]) *Dipartimento di Matematica e Fisica, Università degli Studi Roma Tre, Roma, Italia*
([2]) *INFN, Sezione di Roma Tre, Roma, Italia*

Cosa succede se una comunità di ricercatori e studenti di fisica ha la possibilità di avere sempre a portata di osservazione le tracce lasciate dalle particelle intorno a noi grazie a uno storico rivelatore lasciato sempre in funzione? Per festeggiare i 25 anni della sezione INFN di Roma Tre, abbiamo posizionato proprio all'ingresso del Dipartimento che ospita il corso di Laurea in Fisica di Roma Tre una camera a nebbia. In questa comunicazione racconteremo questa esperienza.

Flusso di particelle attraverso uno schermo dotato di fessure.

Borghi E.
Segrate, MI

Una analisi approfondita, basata sulla applicazione dell'equazione di Schrödinger allo studio del flusso di particelle attraverso uno schermo dotato di fessure, mostra che la detta equazione può descrivere correttamente il passaggio dal caso di particelle dotate di massa piccolissima, che danno luogo in Meccanica quantistca a effetti interferenziali, al caso di particelle dotate di massa abitrariamente grande, che danno luogo in Meccanica classica a tipiche curve gaussiane. Il passaggio dalla risposta quantistica alla risposta classica avviene con continuità al variare della massa. Il concetto di decoerenza appare così essere non necessario.

Bank accounts and leaking buckets.

Lamberti V., Zhengis A., Marino A.
Dipartimento di Fisica "E. Caianiello", Università di Salerno, Salerno, Italia

A simple hydrodynamical model describing leakage of water from a hole in the bottom part of a bucket is studied under the assumption of quasi-stationary non-viscous flow. The differential equation governing the system dynamics is derived from Bernoulli's equation, and the fixed points of the system are identified. Basic calculus concepts are used to analyze the solution of the problem. This model is used to discuss an analog system in economics. By the latter model, one can quantitatively describe the time evolution of the amount of money that average consumers decide to spend based on their available budget. The continuity equation for the leaking bucket problem in hydrodynamics is used to specialize the problem in terms of economic variables. The analogous problem can be solved using parameters that relate to the income and propensity to spend of the average consumers.

Apprendimento concettuale di studenti di scuola secondaria superiore in relazione ad un intervento didattico sulla spettroscopia.

Catena D., Michelini M., Santi L.
Dipartimento di Scienze Matematiche, Informatiche e Fisiche, Università di Udine, Udine, Italia

È stato messo a punto un Modulo di Intervento Didattico (MID) sulla spettroscopia ottica a seguito di numerose sperimentazioni effettuate con il metodo della Design Based Research. Questo studio illustra la valutazione dell'apprendimento concettuale a seguito della sperimentazione con 60 studenti del quinto anno di un liceo scientifico. Un questionario composto da 20 domande a risposta aperta e 10 a scelta multipla è stato somministrato dopo la conclusione delle attività. I quesiti indagano i nodi concettuali noti in letteratura: il meccanismo della visione, i colori della luce, le sorgenti di luce ed i processi di emissione, la funzione dello spettroscopio, il legame tra gli spettri ed i livelli energetici. L'analisi delle risposte è stata effettuata tramite un processo di categorizzazione. I risultati mostrano come la grande maggioranza degli studenti abbia acquisito consapevolezza del significato di uno spettro ottico di emissione e del suo ruolo nell'interpretazione del fenomeno in termini di livelli energetici. Le difficoltà emerse riguardano l'elaborazione di ragionamenti coerenti sul ruolo delle componenti dello spettroscopio e sulla natura discreta dei salti energetici.

Riflessioni sul tema della questione di genere nella scelta delle discipline STEM e nella carriera accademica.

Monti F.
Dipartimento di Informatica, Università di Verona, Verona, Italia

Il tema del genere nelle discipline STEM riguarda sia la scelta dei percorsi di studio sia la progressione di carriera. L'analisi prodotta dal CUN nel 2020 considera i dati relativi al successo negli studi in tutti i campi del sapere, le percentuali di laureati (predominanza maschile in alcune aree disciplinari e femminile in altre, anche scientifiche) e la presenza di uomini e donne lungo la carriera accademica (predominanza maschile nelle posizioni apicali in tutte le aree disciplinari). La letteratura scientifica suggerisce di considerare alla radice della diversità nella scelta dei percorsi di studio e lavorativi i fattori biologici legati in particolare alla struttura degli emisferi destro e sinistro del cervello. Occorre quindi creare le condizioni volte a favorire la libera espressione delle inclinazioni naturali di ciascuno senza repressioni né forzature guardando all'incidenza dei fattori socioculturali e all'istruzione fin dalla scuola primaria. Sebbene vi siano iniziative ministeriali mirate di collaborazione tra università e scuola, esse sono rivolte agli ultimi anni della scuola superiore e intervengono in una fase ormai avanzata della formazione individuale.

Sviluppo di competenze scientifiche tramite l'utilizzo di attività laboratoriali ISLE-based nel liceo scientifico.

Longo F. ([1])([2]), Bologna V. ([1]), Frontino Crisafulli A. ([1])
([1]) *Dipartimento di Fisica, Università degli Studi di Trieste, Trieste, Italia*
([2]) *INFN, Sezione di Trieste, Trieste, Italia*

Dalle Raccomandazione del Consiglio Europeo del 2018 alle Linea Guida Nazionali per il Liceo Scientifico è stata evidenziata la necessità di sviluppare negli studenti competenze scientifiche spendibili nella costruzione della loro consapevolezza di cittadini in una società fondata sulla conoscenza tecnologico-scientifica. Per favorire il raggiungimento di questi obiettivi, abbiamo proposto ai docenti di Fisica del Liceo Scientifico Guglielmo Oberdan di Trieste, la sperimentazione didattica di attività di laboratorio basate sull'approccio ISLE (Investigative Learning Science Environment). Tale sperimentazione ha avuto come scopo principale quello di sviluppare negli studenti competenze scientifiche (secondo le rubriche definite nell'approccio ISLE stesso) e avvicinare gli insegnanti alla pratica didattica di un laboratorio non prettamente dimostrativo. La sperimentazione ha coinvolto 11 docenti, 24 classi (dalla prima alla quinta), e 500 studenti nelle attività progettate su forze, moto, energia, calore e magnetismo. Un questionario sulle competenze scientifiche pre e post attività ha consentito di verificare quanto il laboratorio proposto abbia raggiunto l'obiettivo prefissato.

Tutor di esperienze laboratoriali di fisica per attività di sviluppo professionale dei docenti di fisica.

Di Blasi M. ([1]), Mobilio S. ([2]), De Angelis I. ([1])([3]), Postiglione A. ([4])
([1]) *Dipartimento di Matematica e Fisica, Università degli Studi Roma Tre, Roma, Italia*
([2]) *Università degli Studi Roma Tre, Roma, Italia*
([3]) *INFN, Sezione di Roma Tre, Roma, Italia*
([4]) *INFN, Laboratori Nazionali di Frascati, Frascati, RM, Italia*

In questo intervento presenterò il mio contributo al corso di aggiornamento per docenti di matematica e fisica di scuola secondaria di secondo grado presso il Dipartimento di Matematica e Fisica dell'Università degli Studi Roma Tre. In particolare, ho testato alcuni esperimenti tratti dal libro "Fare Laboratorio" nell'ambito del progetto LSOSAlab, cercando di ottimizzarne i materiali richiesti in modo che fossero semplici da reperire per i docenti a scuola e ho predisposto tutti i kit per svolgere i laboratori del corso. Abbiamo cercato di presentare

ai docenti gli esperimenti introducendo anche un aspetto giocoso da riproporre in classe. Infine, abbiamo supportato i docenti nella realizzazione in prima persona degli esperimenti cercando di evidenziarne anche le possibili problematiche o difficoltà.

Monitoraggio degli apprendimenti di fisica nucleare in popolazioni di studenti immatricolati in corsi STEM.

Teruzzi P., Ludwig N.
Dipartimento di Fisica "Aldo Pontremoli" dell'Università degli Studi di Milano, Milano, Italia

Le indicazioni nazionali per i licei inquadrano la fisica nucleare tra i saperi complementari e il suo insegnamento è relegato a un ruolo marginale. Al termine del corso di studi, la maggioranza dei diplomati possiede una scarsa preparazione sull'argomento. Ciò limita la loro cultura personale, indebolisce la prospettiva degli studi successivi e riduce le competenze di cittadinanza attiva. La sezione di Didattica della Fisica dell'Università degli Studi di Milano ha condotto un monitoraggio su un campione di circa 200 studenti iscritti a corsi STEM, per valutare l'acquisizione delle nozioni di fisica nucleare nel corso di studi precedente all'immatricolazione universitaria. Dalle risposte fornite emerge, pur in presenza di una non trascurabile attività didattica pregressa, un contesto contrassegnato da gravi lacune anche nei contenuti di base. In merito ai contenuti complessi, si osserva una preparazione inferiore a uno standard di accettabilità. Il quadro dettagliato dello stato dell'arte sarà finalizzato a progettare interventi di aggiornamento nuovi nelle finalità, nei contenuti e nelle metodologie, da promuovere a platee di docenti della scuola secondaria di secondo grado.

Gli strumenti raccontano: apprendere la fisica al Museo.

Del Monte R. ([1]), Auteri A. ([1])
([1]) *Museo di Fisica, Centro Musei delle Scienze Naturali e Fisiche, Università di Napoli "Federico II", Napoli, Italia*
([2]) *Socio SISFA, Napoli, Italia*

Il Museo di Fisica del Centro Musei delle Scienze Naturali e Fisiche, Università di Napoli "Federico II", rappresenta uno scrigno di conoscenze scientifiche. La sua collezione di circa 800 strumenti, prevalentemente risalenti all'Ottocento, racconta la storia affascinante degli studi e delle ricerche condotte dagli scienziati che hanno operato nella città di Napoli e nella sua Università. Oltre alla cura, conservazione e studio delle preziose collezioni storiche, il Museo ha come obiettivo fondamentale la divulgazione della Scienza. L'impegno del Museo è quello di rendere la conoscenza scientifica accessibile a tutti i cittadini e le collezioni museali rappresentano uno strumento straordinario. Accanto all'offerta rivolta alle scolaresche di ogni ordine e grado, tante sono le iniziative messe in campo per coinvolgere anche il pubblico generico. Il Museo, per essere al passo coi tempi, persegue la sua missione utilizzando anche le nuove tecnologie, che consentono di raggiungere un pubblico più ampio e offrire esperienze di apprendimento coinvolgenti anche a distanza. Il Museo di Fisica grazie alle attività proposte contribuisce alla formazione di una cittadinanza scientificamente consapevole.

Aula P1 **ore 14:30 – 15:10**

Sezione II
Fisica della materia
Presiede: Cataliotti F.S. (INO-CNR)

Relazione Generale

Quantum firmware: Optimal control for quantum simulators.
Calarco T.
Forschungszentrum Jülich, Universität zu Köln e Università di Bologna
Quantum optimal control has been shown to improve the performance of quantum technology devices up to their limits in terms, *e.g.*, of system size and speed of operation. I will review our recent results with a variety of quantum technology platforms, focusing in particular on ultracold atoms, and introduce our newly developed software for automatic calibration of quantum operations —the fundamental building block of next-generation quantum firmware.

Aula F1 - Augusta Manfredini **ore 15:10 – 19:30**

Sezione I
Fisica nucleare e subnucleare
Presiede: Gianotti P. (INFN, Laboratori Nazionali di Frascati)

Relazioni su invito

▲ **Il bosone X17 nella ricerca italiana: Il caso di PADME e oltre.**
Taruggi C.
INFN, Laboratori Nazionali di Frascati
Nel 2015 un gruppo dell'istituto di ricerca ungherese ATOMKI ha realizzato un esperimento durante il quale ha osservato un'anomalia nel decadimento di atomi di berillio. In particolare, l'angolo di emissione di coppie elettrone-positrone emesse a seguito del decadimento era più ampio di quello atteso. La stessa anomalia è stata poi riscontrata in esperimenti successivi realizzati dal gruppo su atomi di elio e carbonio. Una teoria che spiega questo fenomeno postula l'esistenza di una particella, denominata X17 e di massa pari a circa 17 MeV, che potrebbe essere il mediatore di una nuova interazione tra materia oscura e materia ordinaria. Altri gruppi di ricerca si sono dedicati alla ricerca di questa particella, sia utilizzando apparati ed esperimenti già esistenti (MEG-II, NA64) sia realizzandone di nuovi (ATOMKI@LNL, n_TOF, LUNA-MV). L'esperimento PADME, inoltre, ha effettuato una presa dati per la rivelazione del bosone X17 durante l'autunno del 2022. PADME infatti ha la possibilità di cercare questa nuova particella proprio nel range di massa contemplato dall'esperimento di ATOMKI, ma con un approccio complementare, che verrà descritto nella comunicazione.

Comunicazioni

● **Studio della produzione risonante del bosone X_{17} presso l'esperimento PADME.**
Mancini M. per la Collaborazione PADME
INFN, Laboratori Nazionali di Frascati, Dipartimento di Fisica, Università di Roma Tor Vergata, Roma
La collaborazione ungherese dell'istituto ATOMKI di Debrecen ha osservato anomalie nella distribuzione angolare delle coppie e^+e^- emesse attraverso il processo di Produzione Interna di Coppie dalle diseccitazioni nucleari di ^{8}Be, ^{4}He e ^{12}C. Gli eccessi risultano compatibili con la produzione, e successivo decadimento, di un nuovo bosone di massa 17 MeV (X_{17}). La collaborazione PADME, facendo uno scan energetico nella regione di interesse di massa invariante, si pone come obiettivo di studiare la produzione risonante $e^+e^- \to X_{17} \to e^+e^-$. In particolare, a partire dallo studio dei processi di fondo dovuti alle interazioni note del Modello Standard, si è valutata la sensitività dell'esperimento alla produzione dell'X_{17}. Questi studi hanno permesso di definire le modalità con cui, nella seconda metà del 2022, è stata condotta la presa dati corrispondente. Qualora PADME non osservasse alcun segnale, questo permetterà comunque di porre limiti stringenti all'accoppiamento di X_{17} con gli elettroni.

● **Nuovo setup dell'apparato sperimentale PADME per la rivelazione dell'X_{17}.**
Di Meco E.
INFN, Laboratori Nazionali di Frascati, Frascati, RM, Italy e Dipartimento di Fisica, Università degli Studi di Roma Tor Vergata, Roma, Italy
La Collaborazione ATOMKI ha recentemente confermato la presenza dell'anomalia del ^{8}Be anche nelle distribuzioni angolari dell'^{4}He e del ^{12}C. Tale anomalia può essere interpretata come la creazione e decadimento di una particella intermedia di massa $\sim$ 17 MeV,

di nome X_{17}. Determinare l'esistenza e la natura (vettoriale o pseudo-scalare) di X_{17} è uno degli obiettivi del Run III di PADME ai Laboratori Nazionali di Frascati. Al fine di studiare il canale di decadimento $X_{17} \to e^+e^-$ sono state effettuate alcune modifiche al setup dell'esperimento, in particolare è stato integrato un tagger di particelle leptoniche cariche (ETag) composto da barre di scintillatore plastico (BC-408) lette da Silicon Photo-Multipliers. Tale detector, unito al calorimetro elettromagnetico (ECal), permette la completa identificazione delle particelle prodotte. La comunicazione presenterà i test effettuati per caratterizzare gli elementi di ETag in termini di efficienza e risposta temporale necessari a mettere a punto il Monte Carlo generale dell'esperimento.

Integrazione del bersaglio nella camera di scattering dell'esperimento NUMEN.

Sartirana D. ([1]), Calvo D. ([1]), Agodi C. ([2]), Cappuzzello F. ([2])([3]), Cavallaro M. ([2]), Ferraresi C. ([1])([4])
([1]) *INFN, Sezione di Torino, Torino, Italy*
([2]) *INFN, Laboratori Nazionali del Sud, Catania, Italy*
([3]) *Dipartimento di Fisica e Astronomia "Ettore Majorana", Università di Catania, Catania, Italy*
([4]) *Dipartimento di Ingegneria Meccanica e Aerospaziale, Politecnico di Torino, Torino, Italy*

L'esperimento NUMEN prevede l'upgrade dello spettrometro MAGNEX presente presso INFN-LNS, in particolare della camera di scattering che conterrà un nuovo bersaglio. La nuova camera a geometria sferica è stata progettata per soddisfare le condizioni di lavoro dettate dall'impiego di una linea di fascio ad alta intensità (10^{13} pps) e per lavorare con alto vuoto (10^{-6} mbar). All'interno è stato integrato uno specifico sistema di raffreddamento del bersaglio (crio-refrigeratore). Siccome il livello di radiazione prevista nella zona del bersaglio non è trascurabile, è stato progettato un manipolatore automatico custom per operarne la sostituzione. Integrati alla camera sono presenti anche differenti sistemi utili alla diagnostica e alla calibrazione. Tutti i componenti della camera sono stati progettati e realizzati per essere integrati ai controlli in un sistema di prova presso il Laboratorio Tecnologico dell'INFN di Torino. Sono attualmente in corso le prove di funzionalità a cui seguirà la fase di ottimizzazione del sistema. Successivamente l'insieme sarà trasferito a INFN-LNS per essere installato. Saranno presentati i risultati e le prestazioni ottenuti.

A data-driven method to constrain the antiproton background in Mu2e.

Chithirasreemadam N. ([1])([2]), Donati S. ([1])([2]), Murat P. ([3]), Nigrelli G. ([1]), Pezzullo G. ([4]), Stortini M. ([4]), Ricci A.M. ([1])([2])
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The Mu2e experiment will search for the CLFV neutrinoless coherent conversion of muon to electron, in the field of an Al nucleus. The experimental signature is a monochromatic conversion electron (CE) with energy 104.97 MeV. CE-like electrons could also come from background like cosmic muons, Decay in Orbit of muons in the Stopping Target (ST) or antiprotons produced by the proton beam at the Production Target and annihilating in the ST. The background induced by antiprotons cannot be efficiently suppressed by the time window cut used to reduce the prompt background. So, we are developing a technique for the *in situ* measurement of the pbar background. ppbar annihilation in the ST is the only source of events in Mu2e with two tracks each with a momentum of about 100 MeV/c, and we plan to exploit this unique feature. The idea is to identify and reconstruct multi-track events

and use them to estimate the background from ppbar annihilation. The Mu2e detector is optimised for reconstructing single-track events but we are developing an algorithm to reconstruct multi-track events. This communication will discuss the status and prospects of the *in situ* estimate of the pbar background in Mu2e.

Improvement for Mu2e track reconstruction algorithms.

Kitagawa H. ([1]), Donati S. ([1]), Murat P. ([2]), Ricci A.M. ([1])
([1]) *Università di Pisa, Italia*
([2]) *Fermi National Accelerator Laboratory, USA*

The Mu2e experiment at Fermi National Accelerator Laboratory will search for the Charged Lepton Flavor Violating (CLFV) neutrino-less coherent conversion of a muon into an electron in the field of Al nucleus. The charged particles generated in the Al-stopping target are transported in the tracker by a magnetic field. The tracker consists of a bundle of straw tubes and measures the particle trajectory and momentum. Due to the various fast particles generated from the stopping target, the straw hits produced in the same time scale are counted as hits of a single particle, which can affect track reconstruction performance. This work aims to understand the geometric distribution of the straw hits in the tracker and develop a method to improve the tracker's capacity to distinguish straw hits of various particles at the first stage of the track reconstruction algorithms.

Study of the antiprotons background to the muon-to-electron-conversion search at the Fermilab Mu2e experiment.

Nigrelli G.
Dipartimento di Fisica, Università di Pisa, Italia

The Mu2e experiment at Fermilab will search for the neutrinoless $\mu^- \to e^-$ conversion in the field of an aluminum nucleus. The process violates the lepton flavor conservation stated by the Standard Model, observation of such events would provide guidance on how to extend our incomplete model. Being a Beyond the Standard Model process it is extremely rare, therefore it is important to understand the backgrounds of the experiment. The antiproton background is one of the main backgrounds of Mu2e. The total expected background in Mu2e Run I is 0.11 ± 0.03 events, and the antiproton background, $0.01 \pm 0.003(\text{stat}) \pm 0.010(\text{syst})$. Antiprotons can be produced by proton interactions in the tungsten nuclei of the production target. These antiprotons can contaminate the beam and reach the stopping target where they annihilate and produce signal-like electrons. The antiproton background is sensitive to the vertical misalignment of the Mu2e beamline. We present a data-driven method to estimate the vertical misalignment. In particular, the angular distribution of the reconstructed tracks is sensitive to misalignment and allows to estimate its value.

High-precision cross-section measurements with the ENUBET monitored neutrino beam.

Pupilli F. per la ENUBET Collaboration
INFN, Sezione di Padova

Monitored neutrino beams represent a powerful and cost-effective tool to suppress cross-section related systematics for the full exploitation of data collected in future long baseline oscillation projects. In the last years the NP06/ENUBET project has demonstrated that the systematic uncertainties on the neutrino flux can be suppressed to 1% in an accelerator-based facility where charged leptons produced in kaon and pion decays are monitored in an instrumented decay tunnel. This communication will present the final design of the ENUBET beamline that allows to collect $\sim 10^4$ ν_e and $\sim 6 \times 10^6$ ν_μ CC interactions on a

500 ton LAr detector in about 2 years of data taking. The algorithms setup for high purity identification of charged leptons in the tunnel instrumentation will be described together with the framework for the assessment of the final systematics budget on the neutrino fluxes. We will also present the results of a test beam exposure at CERN-PS of a fully instrumented 1.65 m long section of the ENUBET instrumented decay tunnel. Finally the physics potential of the ENUBET beam with ProtoDUNE-SP and plans for its implementation in the CERN North Area will be discussed.

Observation of high-energy muon neutrinos with the SND@LHC experiment.
Paggi G.
Dipartimento di Fisica e Astronomia "Augusto Righi", Alma Mater Studiorum - Università di Bologna, Italia e INFN, Sezione Bologna, Italia
SND@LHC is a compact and stand-alone experiment to perform measurements with neutrinos produced at the LHC in a pseudo-rapidity region of $7.2 < \eta < 8.6$, complementary to all the other experiments at the LHC. The experiment is located 480 m downstream of IP1 in the TI18 tunnel. The detector is composed of a hybrid system based on an 800 kg target mass of tungsten plates interleaved with emulsion and electronic trackers, followed downstream by a calorimeter and a muon system. The configuration allows us to efficiently distinguish between all three neutrino flavours, opening a unique opportunity to probe the physics of heavy flavour production at the LHC in the region that is not accessible to ATLAS, CMS, and LHCb. The experiment has been collecting data over the 2022 run, the first year of the LHC Run 3. In this communication, detector performance and the first neutrino measurements will be presented.

Measurement of the muon flux with the SND@LHC experiment.
Alicante F.
INFN, Sezione di Napoli e Università degli Studi di Napoli "Federico II"
SND@LHC is a compact and stand-alone experiment to perform measurements with high-energy neutrinos produced at the LHC in an unexplored pseudo-rapidity region of $7.2 < \eta < 8.4$, complementary to all the other experiments at the LHC. The detector is composed of a hybrid system based on an 830 kg target mass of tungsten plates, interleaved with emulsion and electronic trackers, followed downstream by a calorimeter and a muon system. The experiment was installed in the TI18 tunnel at CERN and has seen its first data in July 2022. The first phase aims at operating the detector throughout LHC Run 3 to collect a total of about 250 fb^{-1}. In this communication the measurement of the muon flux in the angular acceptance of the experiment will be presented. Details on the track reconstruction performed in the electronic detectors and in the emulsion target will be given. The measured rates per unit of cm^2 and f^{-1}, and the tracks' angular distributions will be compared between two distinct electronic sub-detectors and with the emulsion reconstructed data. In addition, the Monte Carlo expectations of such muon fluxes are also conferred.

Constraints on NJL four-fermion effective interactions from neutrinoless double beta decay.
Paciosselli L. ([1])([2]), Panella O. ([2]), Presilla M. ([2]), Xue S.S. ([2])([3])([4])([5])
([1]) *Dipartimento di Fisica e Geologia, Università degli Studi di Perugia, Perugia, Italy*
([2]) *INFN, Sezione di Perugia, Perugia, Italy*
([3]) *ICRANet, Pescara, Italy*
([4]) *Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italy*
([5]) *ICTP-AP, University of Chinese Academy of Sciences, Beijing, China*
We study the contribution of a heavy right-handed Majorana neutrino to neutrinoless double beta decay ($0\nu\beta\beta$) via four-fermion effective interactions of Nambu–Jona-Lasinio (NJL)

type. In this physical scenario, the sterile neutrino mediates this nuclear transition through gauge, contact, and mixed interactions, for which we compute the contributions to the half-life by using standard approximations in $0\nu\beta\beta$ calculations. Using the lower limits on the half-life of $0\nu\beta\beta$ from KamLAND-Zen and the next-generation experiments, we then constrain the effective right-handed coupling between the sterile neutrino and the W boson: $\mathcal{G}_R^W$. Eventually, we show that the obtained bounds are compatible with those found in the literature, which highlights the complementarity of this $0\nu\beta\beta$-driven study, *i.e.*, at low energies (~ 100 MeV), with high-energy experiments.

Aula F8 - Maria Marinaro **ore 15:10 – 19:30**

Sezione II
Fisica della materia
Presiede: Terrasi A. (Università di Catania)

Relazioni su invito

▲ **Plasmonic immunosensors in biosensing.**
Velotta R.
Dipartimento di Fisica "E. Pancini", Università di Napoli "Federico II"
Plasmonic immunosensors are a type of biosensor that use plasmonic nanoparticles to detect biological target such as proteins, DNA, and viruses. When plasmonic nanoparticles are functionalized with anti-bodies that can bind to specific biological molecules, they can be used to detect the presence of specific targets. The principle behind plasmonic immunosensors is that when plasmonic nanoparticles bind to biological molecules, their surface plasmon resonances change, resulting in a shift in the wavelength of the light they scatter or absorb. This shift can be detected by optical instruments or even by naked eyes, the latter way being more suitable when the target induces nanoparticle aggregation. In this talk, I will review some advances we have made in this area with special reference to colorimet-ric biosensors —based on gold nanoparticles in colloidal solution as well as in lateral flow assays—, and fluorescence biosensors in which the yield is enhanced by plasmonic. It will be shown that plasmonic can be exploited to realize devices (and kits) that can detect targets like bacteria, viruses, and molecules with remarkable sensitivity and specificity.

▲ **Studio del drogaggio in elettrodi trasparenti per applicazione alle tecnologie fotovoltaiche.**
Tringali F., Lo Mastro A., Miritello M., Franzò G., Terrasi A.
Università degli studi di Catania, Dipartimento di Fisica e Astronomia "Ettore Majorana"
Le tecnologie fotovoltaiche ricoprono oggi un ruolo centrale nella sfida verso una produzione energetica sostenibile. Tra gli strati più importanti all'interno della cella solare si trovano i TCO (Ossidi Trasparenti Conduttivi), tra cui il più utilizzato è l'ossido di indio drogato con stagno (ITO). L'obiettivo del nostro lavoro sui TCO era studiare i meccanismi di drogaggio che regolano la conducibilità di questi materiali, allo scopo di ottimizzarli. Film sottili di ossido di indio (In_2O_3), depositati tramite sputtering, sono stati sottoposti ad impiantazione ionica di ioni zinco (drogaggio estrinseco) e di ioni argon (drogaggio intrinseco). Lo studio ha confermato un notevole aumento nelle proprietà elettriche del film, dovuto alla presenza di drogante, ma ha anche mostrato risultati sorprendenti a seguito del drogaggio intrinseco, relativi alla creazione di vacanze di ossigeno. Infatti, una resistività molto bassa ($1,5 \cdot 10^{-3}\,\Omega$·cm) e un'elevata trasparenza (85%) sono state ottenute con una dose di 0,5 at.% di ioni Ar^+. Questo risultato mostra come il drogaggio intrinseco sia una strada percorribile e affidabile per realizzare ossidi trasparenti altamente conduttivi.

▲ **Novel high-intensity lasers for plasma acceleration.**
Gizzi L.A.
Istituto Nazionale di Ottica, INO, Consiglio Nazionale delle Ricerche, Pisa, Italy
High-intensity lasers are enabling unique developments in fundamental research and multidisciplinary applications. Among these applications, laser-driven plasma acceleration is

now becoming a mature technology to deliver light sources, like the ESFRI EuPRAXIA Compact European Plasma Accelerator. Effort is ongoing to develop high-intensity lasers capable of delivering ultrashort, petawatt-scale laser pulses at high repetition rate, from kHz and beyond, with high average power, kW and beyond. Currently, Ti:Sa-based systems, with diode-pumped pump lasers, are approaching the specifications required for demonstration of facility operation. In the longer term, more scalable and efficient architectures will be required, based on direct diode-pumping of gain materials capable of chirped pulse amplification. Coherent combination of fibers, OPCPA or Tm-doped crystals or ceramics are being investigated to fulfill future needs of wall plug efficiency, lifetime and cost requirements. An overview will be given on the latest advances in the context of national and European infrastructure developments for fundamental studies and biomedical and industrial uses of intense lasers.

Comunicazioni

Non-thermal fusion burning processes, relevant collective modes and gained perspectives.

Coppi B. ([1]), Basu B. ([1]), Cardinali A. ([2]), Ricci V. ([2])
([1]) *MIT Cambridge, Massachusetts, USA*
([2]) *CNR, Istituto Sistemi Complessi, Italy*

In fusion burning plasmas meaningful and accessible regimes can be identified by considering the self-organization processes and the new modes, or new forms of known modes that can emerge. Resonant mode-particle interactions that involve reacting nuclei can lead to reactivities that allow for effective burn conditions of different kinds of reacting plasmas. A relevant analysis refers to a DT axisymmetric toroidal plasma and to the excitation of ballooning modes where the perturbed density is a periodic function of the poloidal angle, that is radially localized. These modes are shown to be ballooning along the magnetic field and treated as superpositions of waves with the same frequency but propagating along the field with different phase velocities. The relevant mode particle interactions are found to modify the height and the longitudinal width of the mode amplitude and constitute a direct (linear) process to transfer energy from the produced alpha-particles to the reacting nuclei without the inefficiencies of nonlinear processes. An interpretation of relevant experimental observations is given that is connected to the onset of appropriate ballooning modes.

Non-thermal fusion processes and innovations considered for the ignitor program.

Ferraris P. ([1]), Coppi B. ([2]), Faelli G. ([1]), Boggio-Sella E. ([1]), Spigler R. ([3])
([1]) *Consorzio Ignitor*
([2]) *MIT Cambridge, Massachusetts, USA*
([3]) *CNR*

Ignitor has produced the first complete design of a machine capable of approaching ignition regimes based on normally known conditions and adopting well-tested structural and current conducting materials. The design, referred to as Ignitor EVO, is being updated consistently in order to take the results of new and significant experiments into account and to benefit from developments of technology and materials science. Given the ability of high-field compact machines to produce well-confined plasmas, Non-thermal ("Cool") Fusion processes that have been identified theoretically, and would allow approaching ignition under milder conditions than those based on the properties of thermonuclear plasmas, can be investigated with them. Another important issue is that of inducing high currents in low- and high-density plasmas and investigating the transitions between the two regimes in order to adopt

the most appropriate current drive procedures and means. Given the pressing need to investigate meaningful burning plasmas, the choice of superconducting machine components and materials to be employed has been based on assessing the time needed to develop relevant magnet systems.

High-entropy oxide-based electrode materials for capacitive de-ionization of brackish water.

Triolo C. ([1]), Santangelo S. ([1]), Petrovičovà B. ([1]), Musolino M.A. ([1]), Rincón I. ([2]), Atxirika A. ([2]), Gil S. ([2]), Belaustegui Y. ([2])
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Water pollution and scarcity are serious concerns for the growing world population. Due to its environmental friendliness, high efficiency, easy regeneration of the electrodes and ambient operating pressure, capacitive de-ionization (CDI) is one of the most promising desalting techniques proposed to increase the availability of fresh water. This work focuses on the preparation of high-entropy oxides (HEOs) and carbon/HEO composites and the evaluation of their specific capacitance in view of their possible use as CDI electrode materials. Spinel-type HEO nanoparticles and nanofibers are produced by sol-gel method and electrospinning technique, respectively, to study the effect of the HEO size and morphology. Composite nanofibres are further prepared with embedded spinel- and rocksalt-HEO grains to investigate the influence of the lattice structure and of the host carbon matrix. The comparative discussion of the results indicates that the size of the HEO grains, indirectly influenced by the lattice structure, plays a key role. The presence of the carbon matrix improves the electrochemical performance, favouring the electrode electrical conductivity and limiting the sintering effects.

Magnetic analysis of MgFe hydrotalcites in bulk and dispersed in thin films within a keratin matrix.

Dinelli F. ([1])([2]), Modestino M. ([2]), Galluzzi A. ([2]), Posati T. ([3]), Seri M. ([3]), Zamboni R. ([4]), Sotgiu G. ([4]), Polichetti M. ([2])
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([3]) *Istituto per i Materiali Nanostrutturati, CNR, Bologna*
([4]) *Istituto per la Sintesi Organica e la Fotoreattività, CNR, Bologna*

Hydrotalcites (HTlc) represent a class of nanostructured layered materials that may be employed in green and biotechnologies. We report an investigation on HTlc made of Mg and Fe, recently employed to improve the growth *in vitro* of osteoblasts within a keratin sponge. We have carried out an analysis of the bulk materials and of HTlc dispersed in keratin and spincoated on a silicon substrate. The study of the powders has been carried out with a physical property measurement system, using a vibrating sample magnetometer that allows exploring the magnetic properties down to 2.5 K. The data gathered prove that these HTlc are paramagnetic, whereas keratin shows a slightly pronounced response. Optical and atomic force microscopy provide a detailed picture of clusters randomly dispersed in the films with various dimensions. The magnetic properties of these films have been characterized with Nano Magneto-Optical Kerr Effect (NanoMOKE) down to 7.5 K. The data collected show that the local magnetic properties can be mapped with a micrometric resolution, distinguishing HTlc regions from keratin ones. This approach opens up new perspectives in the characterization of these composite materials.

Underwater adsorption, adhesion and cohesion of protein films on solid surfaces.

Barragàn D.
Università della Calabria

Bioadhesion is the stable attachment of an organism to a surface due to macromolecules. This mechanism has attracted much attention recently due to the ongoing progress in the study of marine bioadhesives. This research work is focused on an adhesive protein from a flatworm of the *Macrostomum* genus, distributed in the intertidal zone. Its reversible adhesion to solid substrates in wet conditions involves two proteins, Mlig-1 and Mlig-2. The aim is to quantify the adsorbed mass, adhesion, and cohesion energy of repeating domains in these proteins, which are expected to enable *Macrostomum* bioadhesion. This study is conducted using a surface forces apparatus (SFA) and an atomic force microscope (AFM). In parallel, collagen, the most abundant protein in mammalians, was analyzed as a molecular structural model to understand adhesion mechanisms in the aqueous phase. Employing the AFM, the mechanical characteristics of individual tropocollagen type I and type III nanofibrils adsorbed on a mica substrate were characterized in terms of persistence length and intrinsic curvature. This information will prove essential for the design of collagen-based biocompatible and biodegradable adhesives.

Metamaterials in terahertz photonics: From fundamental physics to applications.

Missori M. ([1])([2]), Pilozzi L. ([1])([3]), Antunez Vazquez D. ([2]), Del Re E. ([1])([2]), Conti. C. ([1])([2])([3])
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([2]) *Department of Physics, Sapienza University of Rome, Italy*
([3]) *Research Center Enrico Fermi, Rome, Italy*

Diffraction of light by corrugated surfaces is a key optical phenomenon. Recently, it inspired the design of artificial planar or staked materials composed by spatially arranging meta-atoms allowing manipulating light on a subwavelength regime. In the terahertz (THz) band, applications were targeted to device realization for wave deflection, focusing, amplitude manipulation, and dynamic modulation. Since THz metamaterial structures have typical sizes of hundreds microns, they are within the reach of current three-dimensional (3D) printing technologies and allow a cheap and rapid fabrication using polymers, ceramics, metals, and composites. In this talk, the fundamental physics of patterned surfaces and of their vertical stacking will be presented with a focus on possible applications. Through analytical solutions of the Maxwell equations and THz time-domain spectroscopy measurements we will show pulses propagation in multilayer structures, transitions from Fano resonances to Bound states in the continuum (BIC) in metasurfaces, and the far-field super-resolution in THz imaging systems based on structured light obtained by near-field metasurfaces for cultural heritage applications.

Wave field and propulsion mechanism of capillary surfers.

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([2]) *Consiglio Nazionale delle Ricerche - Istituto di Nanotecnologia, CNR-NANOTEC, Rende, CS, Italy*
([3]) *PMMH, CNRS, ESPCI Paris, Université PSL, Sorbonne Université, Université de Paris Cité, Paris, France*

Capillary surfers are wave-driven particles at a vibrating fluid interface that have been recently introduced. These active particles are characterized by high tunability and have the

potential to fill the gap between overdamped and inertial active systems. In addition, they exhibit multistability since their interaction forces are long-ranged and spatially oscillatory. Capillary surfers are asymmetric solid objects. It has been suggested that their propulsion is due to asymmetric wave generation on the liquid surface, which would result in an asymmetric transfer of momentum from the surfer to the liquid and net radiation stress. We check this propulsion mechanism by measuring the wave field of capillary surfers using a surface reconstruction technique. Wave field measurements are performed by varying forcing frequency and amplitude and with surfers with different shapes. Indeed, in all cases, the wave field asymmetry is compatible with the direction of the surfer propulsion. A comparison of the measured wave field with an existing theoretical model is also attempted.

Ultra-thin Zr-doped indium oxide films as transparent electrode for Si-based solar cells.

Lo Mastro A. ([1])([2]), Tringali F. ([1])([2]), Lombardo S. ([3]), Miritello M. ([2]), Franzó G. ([2]), Bengasi G. ([4]), Colletti C. ([4]), Foti M. ([4]), Terrasi A. ([1])([2])
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My work aims to reduce the use of indium, listed among raw critical materials, in transparent electrodes for solar cells, replacing the standard ITO layer with a thinner one of a novel TCO: Zr-doped indium oxide (IZrO). The synthesis is carried out via RF and DC co-sputtering by separated targets, with annealing at 200 degrees after the deposition. These techniques are compatible with large-scale industrial processes. Thin IZrO films (from 10 to 100 nm) were grown on glass substrates and widely characterized. We found that the resistivity (around 5E-4 ohm · cm) is comparable to ITO also for ultra-thin samples. IZrO films were also deposited onto silicon bifacial solar cell substrates, replacing the ITO film. External quantum efficiency of these proof of concepts devices was tested. From early stage results, IZrO as top electrode results in excellent EQE in the 400–800 nm spectrum, with evident efficiency losses only above 800 nm. Such losses are driven by thin films interference, degrading EQE in layers of not optimized thickness. To address this issue, I am now working on coupling In free materials (*e.g.*, silicon oxide) to IZrO thin layers, so as to match anti-reflection thickness.

Molybdenum oxide as hole selective contact for silicon hetero-junction solar cells.

La Manna S. ([1])([2]), Franzó G. ([2]), Terrasi A. ([1])([2]), Lombardo S. ([3]), Corso R. ([1])([3]), Scuto A. ([3]), Bengasi G. ([4]), Colletti C. ([4]), Foti M. ([4]), Miritello M. ([2])
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([4]) *3SUN s.r.l., Catania, Italy*

My research activity is focused on replacing *p*-doped a-Si:H with sub-stoichiometric MoO_x as alternative hole-selective contact in SHJ solar cells. Its wide band gap and high work function result in a strong energy barrier, blocking electrons and allowing holes transport. Plus, MoO_x is highly transparent and no toxic gasses are used during the synthesis. Oxygen vacancies generate donor defect states, improving conductivity but also degrading the optical transparency. The electron barrier is ruled by MoO_x WF, itself depending on oxide stoichiometry. I controlled MoO_x thin films composition by tuning the Ar pressure during RF sputtering of a stoichiometric MoO_3 target. Films composition was probed by RBS and

the Mo oxidation states by XPS. These characterizations allowed me to optimize the balance between transparency and electrical conductivity of MoO_x. Particular attention will be addressed to investigate the role of the Si/MoO_3 interface, responsible for surface passivation and hole selectivity. Finally, I will show an EQE improvement in the 300–600 nm range for a proof of concept solar cell containing MoO_x membrane, in comparison with a traditional cell with *p*-doped a-Si:H layer.

Design and construction of a ZIF supported Fe_3O_4/SnO_2 composite as advanced materials for high-performance supercapacitor.

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Public concerns in sustainable development and energy crisis in civilization push research to rapidly focus on energy storage and conversion from renewable sources. Supercapacitors, which are known as electrochemical capacitors or ultra-capacitors, have received extensive attention due to their long cycle life, high power density, reasonable operational protection and ultra-fast charge-discharge rate. Metal-Organic Frameworks (MOFs) have recently gained growing attention and used in many fields due to their high surface area, customizable pore sizes and open metal sites. Herein, we propose highly conductive and easy to be obtained Zeolitic Imidazolate Framework (ZIF) supported Fe_3O_4/SnO_2 composite as advanced materials of high-performance supercapacitor prepared by means of a scalable, economic, solvothermal approach and carefully characterized using different techniques. Cyclic voltammetry and galvanostatic charge-discharge tests were performed using a potentiostat/galvanostat to evaluate the electrochemical performance. We found that our electrode show an excellent pseudocapacitance properties and high specific capacitances.

Neutron imaging for the catalysed hydrogen conversion in metal organic frameworks.

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Time-resolved neutron imaging was used to investigate the ortho-para hydrogen conversion (opC) in the HKUST-1 metal organic framework (MOF) at the IMAT beamline of the ISIS Neutron and Muon Source. Currently MOFs are attracting interest as potential hydrogen storage materials, making it necessary to investigate the framework-dihydrogen interactions. MOFs are known to act as catalysts for the opC. Energy-selective neutron imaging allowed us to characterize the conversion rate as a function of time, for different areas of the sample. Results reported for hydrogen at 17 K show that the ortho-hydrogen conversion rate depends linearly on the ortho concentration and has an average characteristic conversion time of 58 minutes, significantly lower than that of the free hydrogen (ca. 79 hours). Moreover we show that this technique provides a unique insight into the adsorption and conversion kinetics, and that the possibility to explore the spatial distribution of the sample renders it particularly appealing for industrial and engineering applications.

Real space-time subfemtosecond imaging of electronic motion in molecules.

Pisarra M. (1), Martin F. (2), Martin-Jimenez A. (3), Luo Y. (3), Garg M. (3), Kern K. (3)(4)

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([2]) *Departamento de Química, Universidad Autónoma de Madrid, and Imdea Nano, Madrid, Spain*
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Seeing electron motion at its natural length and time scales is a long-awaited dream of natural sciences. Current attosecond techniques allow to generate and track electronic motion in real time with incredible time resolution (200 as), but not in real space. STM techniques can locally probe the electron density in molecules and solids with picometer resolution, but cannot provide the dynamical information at the ultrafast time scale of the electronic motion. In this work, we break this space-time limitation by combining STM and attosecond technologies. We show that the coherent electronic motion generated by laser pulses can be locally and non-invasively probed with both picometer and 300 attosecond resolution, allowing a direct visualization of electron dynamics without reconstruction. We apply our technique to self-assemblies of PCTDA molecules deposited on a Au(111) surface. By DFT calculations we are able to identify the specific electronic states participating in the coherent oscillations. Through an effective two-state model and *ab initio* dipole couplings we are able to predict the population of each state as a function of the laser pulse delays.

● **Eco-friendly carbon-based supercapacitors: Electrochemical properties and charge storage mechanisms.**

Granata V. ([1]), Landi G. ([2]), Barone C. ([1]), Avallone G. ([1]), La Notte L. ([3]), Palma A.L. ([3]), Sdringola P. ([3]), Carapella G. ([1]), Puglisi G. ([3]), Pagano S. ([1])
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In the framework of efficient and environmentally sustainable solutions aimed to reduce the impact on the production and disposal of electronic components, carbon-based supercapacitors have been investigated, fabricated, and tested. Functional materials obtained from renewable resources have been used to ensure their sustainability. Chitosan, casein, and carboxymethyl cellulose have been employed as binders within the electrode in combination with activated carbon extracted from coconut shell. The electrochemical properties of devices based on the different binders are compared by using cyclic voltammetry, galvanostatic charge/discharge curves and impedance spectroscopy. The supercapacitors with hydrogel electrolyte and chitosan binder are characterized by a gravimetric capacitance value ranging between 80 and 100 F/g, a series resistance contribution lower than 1Ω and endurance higher than 12000 cycles. The best-performing device can deliver ca. 5.2 Wh/kg at a high-power density of 1256 W/kg. A correlation between the electrochemical performances and charge storage mechanisms (involving faradaic and non-faradaic processes) at interface electrode/hydrogel has been discussed.

● **Electron diffraction and fast calorimetry of molecular compounds of pharmaceutical interest.**

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Differential scanning calorimetry (DSC) is employed for material characterization for its ability to study physically relevant phenomena in a controlled manner. Further improvements come from chip calorimetry: flat geometry and reduced sample mass allow to reach scan rates as high as 10^5 K/s, better suppressing reorganization or degradation processes; for this ability it is called fast DSC. Electron diffraction (ED) has undergone significant development in the last 20 years thanks to improvements in data collection strategies, development of new single electron detectors, and reduction of electron dose on the sample, permitting to obtain reliable crystalline structures of organic materials, despite their beam sensibility. Moreover, it is now possible to acquire data from nanocrystals too small even for the large-scale X-rays facility. We used ED, DSC, and fast DSC to characterize the micro- and macroscopic properties of active pharmaceuticals ingredients, of huge interest for the importance for health but also for the richness of phenomena shown. Vemurafenib has been chosen as a case study to show the amount of information that can be obtained and their complementarity.

Studio delle interazioni magnetiche in campione di nanoparticelle $Fe_3O_4 - OA$ in campo magnetico DC e AC.

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Lo studio delle nanoparticelle magnetiche, caratterizzate dallo stato superparamagnetico a temperatura ambiente, ha attirato sempre maggiore attenzione negli ultimi decenni per la possibilità di sviluppo di un gran numero di applicazioni in ambito medico e tecnologico. L'analisi delle loro proprietà magnetiche attraverso tecniche in campo DC ed in campo AC permette di ottenere informazioni sulle interazioni magnetiche tra le nanoparticelle. Lo studio svolto su un campione di nanoparticelle di Fe_3O_4 ricoperte da acido oleico ha permesso di evidenziare tecniche in campo DC e AC utili per determinare la presenza di uno stato misto di interazioni all'interno dello stesso campione, confermato dal confronto qualitativo tra i risultati delle due tecniche. In particolare, uno studio approfondito della risposta AC del campione, al variare della frequenza e del campo DC sovrapposto, ha permesso di determinare i tipi di interazioni osservati dall'analisi DC.

Synthesis and characterization of a boroxine-based 2D covalent framework.

Zio T. ([1]), Di Giorgio C. ([2]), Jugovac M. ([3]), Menteş T.O. ([3]), Locatelli A. ([3]), Sala A. ([2]), Africh C. ([2]), Comelli G. ([1])([2])

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Since the discovery of borophene, researchers have explored several 2D materials that combine boron with other elements of the periodic table. In this scenario we synthetized a novel 2D boron-oxide covalent framework via a bottom up approach on Pt(111). This 2D material exhibits both an amorphous structure, where boroxine rings (B_3O_3) act as building blocks of a vitreous 2D network, and a crystalline structure, where boroxine rings are organized in a 6-fold symmetry. Theoretical studies have revealed several possible applications of the two-dimensional crystalline framework of boroxines. In the context of issues related to the climate crisis, the 2D crystalline framework of boroxines can be recognized as an emerging material for efficient CO_2 capture along with several other greenhouse gasses. By means of Scanning Tunneling Microscopy (STM), X-ray Photoelectron Spectroscopy (XPS), Photoelectron Emission Microscopy (PEEM) and Low Energy Electron Microscopy (LEEM) we

will report preliminary experimental results on the synthesis method, the vitreous-crystalline phase diagram and the chemical reactivity of this 2D boron-oxide covalent framework.

● **Fabrication and investigation of a polar metal system based on amorphous LAO/crystalline $BaTiO_3$ heterostructure.**

Sambri A. ([1]), Chen Y. ([1]), Kumar D. ([1]), Di Gennaro E. ([2]), Rubano R. ([2]), Paparo D. ([3]), Strokov V. ([4]), Salluzzo M. ([1]), Miletto Granozio F. ([1])
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([4]) *Paul Scherrer Institute, Villigen PSI, Switzerland*

The coexistence of metallicity and ferroelectricity has been thought to be impossible for a long time, as the long-range Coulomb electrostatic forces favoring the polar structure were expected to be fully screened by free electrons. In other words, the presence of itinerant charge carriers into a ferroelectric insulator was expected to quench ferroelectricity. Indeed, despite the prediction of a theoretical work back to 1965, indicating no fundamental incompatibility between metallicity and polar distortions, polar metals are a quite recent topic, the interest in which has been renewed by the prospective of multifunction integration in the same system. Here we report on a so-far not reported polar system, hosting a two-dimensional electron gas (2DEG), based on the oxide heterostructure a-$LaAlO_3$/c-$BaTiO_3$/$SrTiO_3$ (a-LAO/BTO/STO), where "a-" stands for amorphous, while "c-" for crystalline. A number of characterization techniques helped us to shed some light on the electronic properties and on the origin of the 2DEG in such new example of polar metal heterostructure.

● **Composizione dell'etere.**

Abate G.
Aversa

Definito l'Etere come lo spazio esistente nell'universo non occupato dalla materia, visto che è in grado di veicolare energia senza perdite in ogni direzione non può essere vuoto ma deve avere una composizione corpuscolare. Chiamata pe la particella che lo compone, in scala dimensionale, mentre il neutrone è la più grande delle particelle contenute nell'atomo, la pe è la particella più piccola esistente nell'universo con massa e carica elettrica: massa finita puntiforme, carica elettrica negativa, disposizione spaziale vincolata ai vertici di un tetraedro regolare. L'etere così composto è un sistema perfettamente elastico, conservativo, isotropo ed omogeneo che soddisfa sempre senza incongruenze la fisica di Newton, Coulomb, Einstein, Bohr, Maxwell e di quanti altri si sono occupati e si occupano di fisica atomica e campi elettromagnetici, senza incongruenze tra questi nell'analisi dello stesso fenomeno. Se un campo elettromagnetico è una perturbazione che si diffonde trasmessa dalle particelle dell'etere, si può affermare che la velocità della luce non è la massima raggiungibile ma solo un limite posto dall'inerzia della massa delle pe e dalla distanza reciproca a cui sono poste.

Aula F4 - Henrietta Leavitt **ore 15:10 – 19:30**

Sezione III
Astrofisica
Presiede: Calivà A. (Università di Salerno)

Comunicazioni

Evaluation of Birks' constant for the LYSO:Ce crystals of the CSES-LIMADOU HEPD-02 payload with test beam measurements.
Lega A. ([1])([2]), Nozzoli F. ([2]), Iuppa R. ([1])([2]), Ricci E. ([1])([2]), Follega F.M. ([1])([2]), Gebbia G. ([1])([2]), Zuccon P. ([1])([2]), Rossi F. ([1])([2])
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([2]) *INFN TIFPA*
The usage of LYSO:Ce crystal detectors as high-performance scintillators started about 30 years ago. By now, many experiments in HEP (*e.g.*, CMS, srEDM, COMET, KLOE-2) and some medical physics apparatus (*e.g.*, TAC or CT) are mounting or designing new detectors with these crystals. This material has excellent properties, *i.e.*, density of 7.4 g/cm^3, light yield ∼40000 ph/MeV, decay rise time < 100 ps, decay time ∼40 ns and high radiation tolerance. Such characteristics make this material suitable also for space-based astroparticle physics experiments, *e.g.*, the HEPD-02 payload of the CSES-02 mission. On the other hand, these crystals could present high-quenching phenomena for highly ionizing particles. This effect is described by empirical laws, *e.g.*, Birks' formula, which contains numerical constants that vary for each material. The LIMADOU Collaboration performed test beam measurements to study these parameters. In this work, we present the estimation of Birks' constant of the LYSO crystals mounted in the HEPD-02 payload.

Test e simulazione ottica del photon detection system di DUNE.
Meazza L.
Dipartimento di Fisica G. Occhialini, Università degli Studi di Milano Bicocca, Italia e INFN sezione di Milano Bicocca
Il Far Detector di DUNE si basa sulla tecnologia delle Time Projection Chamber ad Argon Liquido (LArTPC): particelle cariche che attraversano il rivelatore ionizzano l'argon liquido e la carica di ionizzazione è utilizzata per ottenere una ricostruzione 3D dell'interazione dei neutrini. L'argon liquido è anche un eccellente scintillatore sebbene la luce emessa nel VUV sia di difficile rivelazione. Il Photon Detection System (PDS) è il rivelatore di luce di DUNE ed è basato su un sistema di trapping che utilizza materiali WLS e filtri dicroici (X-ARAPUCA). Nel 2022 sono state effettuate le prime misure di photon detection efficiency (PDE) dell'X-ARAPUCA di DUNE in Italia con un apparato costruito presso il Dipartimento di Fisica di Milano Bicocca, producendo luce di scintillazione da argon ad alta purezza attraverso una sorgente di Am241. La misura assoluta della PDE è particolarmente complessa e richiede una simulazione ottica della camera di test oltre che del modulo testato. In questa comunicazione vengono descritti i risultati della campagna di misura e la simulazione ottica dell'apparato, e discusse le performance del PDS nel suo complesso.

Track reconstruction in the HA-TPC of T2K with Machine Learning.
Feltre M.
Università di Siena e INFN Padova
T2K Collaboration is working on the Upgrade of its Near Detector (ND280), with a new active target, a time-of-flight detector, and new gas-based detectors called High-Angle Time

Projection Chambers (HA-TPCs). These TPCs have a gaseous active volume contained within a Field Cage, that detects charged particles at large angles with respect to the neutrino beam. They are readout by 8 Resistive MicroMegas sensors per each anode. Crucial tasks for HA-TPCs are the Particle Identification and Spatial Resolution. This contribution will focus on the application of ML algorithms, such as deep neural networks for track reconstruction. In order to train and evaluate the performances of such methods, a simulation of the TPC and the ERAM sensor response has been developed using Garfield++ framework, with detailed studies on the signal formation in the anode. The method is showing promising results, aligned with the already validated methods (*e.g.*, the Pad Response Function). Therefore, the application of ML in the HA-TPC of T2K is expected to continue and to show improved results in the identification and analysis of charged particles produced by neutrino interactions.

The ICARUS T600: the state of the art.

Cicerchia M. on behalf of the ICARUS Collaboration

Università degli studi di Padova, Dipartimento di fisica e astronomia G. Galilei e INFN sezione di Padova

The ICARUS T600 detector is the largest LAr TPC ever built. Its excellent spatial and calorimetric resolution allows near-perfect visualization of tracks from charged particles. In 2010 ICARUS first collected data at LNGS performing a sensitive search for LSND-like anomalous νe appearance in the CNGS beam contributing to allowed neutrino oscillation parameters. After a significant overhaul at CERN, the T600 detector has been installed at Fermilab. The commissioning phase lasted almost two years, initially focusing on the cryogenic systems. Afterwards, ICARUS started to take data on-axis from the BNB and off-axis from the NuMI beams. Event selection, reconstruction and analysis algorithms are presently undergoing robust development. The first study of ν-oscillation will address the short baseline reactor experiment NEUTRINO-4's claim, while performing measurement of ν-cross sections with the NuMI beam. Eventually, ICARUS will search for evidence of sterile neutrinos, within the SBN program. In this presentation, an overview of the ICARUS project and recent results will be presented.

Developing transition-edge sensors for high-precision electron detection in the PTOLEMY project.

Pepe C. ([1])([2]), Garrone H. ([1])([2]), Monticone E. ([2]), Rajteri M. ([2])

([1]) *Dipartimenti di Elettronica e Telecomunicazioni, Politecnico di Torino, Italia*

([2]) *Istituto Nazionale di Ricerca Metrologica, Torino, Italia*

The PTOLEMY project aims to detect Cosmological Relic Neutrinos, providing a snapshot of the universe's first second after the Big Bang. To achieve this, a precise electron detector with an energy resolution of 0.05 eV at 10 eV is required. Transition-edge sensors (TES) are microcalorimeters that exploit the superconducting transition of a metallic film and have demonstrated high-precision energy measurement capabilities. In this work, we report on our latest achievements in developing TES for the PTOLEMY project. We are exploring TiAu TES and using simulation software to model TES performances. Our simulations show that an energy resolution of 0.05 eV can be achieved with a 20×20 μm^2 TES with a critical temperature of 50 mK. We have already achieved an energy resolution of 0.114 eV for a 20×20 μm^2 TES with a critical temperature of 92 mK with IR photons. Our next steps include further optimizing this device and demonstrating its ability to reach this high energy measurement precision.

Anodic bonding to manufacture Laue lenses for high energy astrophysics.
Mazzolari A. ([1])([2])([3]), Frontera F. ([1])([3]), Romagnoni M. ([1]), Guidi V. ([1])([2]), Tamisari M. ([1])([2]), Ferro L. ([1]), Moita M. ([1]), Rosati P. ([1]), Guidorzi C. ([1])([2])([3]), Bandiera L. ([2]), Malagutti L. ([2]), Orlandini M. ([3]), Virgilli E. ([3]), Auricchio N. ([3]), Caroli E. ([3]), Stephen J.B. ([3]), Verbeni R. ([4])
([1]) *University of Ferrara, Department of Physics and Earth Sciences, Ferrara, Italy*
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([4]) *European Synchrotron Radiation Facility, ESRF, Grenoble, France*
The hard X-/soft gamma-ray band is still not well explored in astrophysics despite the fact that several science questions that can be settled in this energy band, *e.g.*, the origin of the 511 keV positron annihilation line from the Galactic Center region, are still unanswered. The main reason is that this band has been explored so far with non-focusing instruments, that can achieve a limited sensitivity and angular resolution. Our goal is the development of a focusing telescope based on a Laue lens made of bent crystals of silicon and germanium, that diffract photons in the 50–700 keV band, with unprecedented angular resolution and sensitivity to continuum spectrum and to lines. We will report on results about the elastic bending of the crystals to give them the curvature of the lens and accurately bonding them to their substrates, with one of their main surfaces having the required curvature of the lens, through anodic bonding techniques, with no use of glue, and with the required angular orientation of the crystals in the lens.

Characterization of Silicon Photomultipliers (SiPM) for gamma-ray detection in aerospace.
Guerrisi C. ([1]), Bissaldi E. ([1])([2]), Di Venere L. ([2]), Loporchio S. ([1])([2]), Giordano F. ([2])([3]), Gargano F. ([2])
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([3]) *Dipartimento Interateneo di Fisica, Bari, Italy.*
Silicon photomultipliers (SiPM) are state-of-the-art light sensors characterized by high sensitivity in single photon detection and extended dynamic range. Thanks to their promising potential in terms of performance, durability, and low production cost, SiPMs are an excellent candidate for gamma-ray detectors in satellites. SiPMs might replace conventional vacuum photomultiplier tubes (PMTs) for low photon fluxes detection. We present a full characterization of a SiPM device technology developed in Italy by Fondazione Bruno Kessler and Broadcom jointly refined the NUV-HD technology that strongly suppresses optical crosstalk. This device is a High-Density (HD) NUV SiPM, based on a micro-cell of 40 μm and with an area of 6×6 mm^2, with low dark noise and high PDE peaking in the NUV band. In particular, the parameters affecting the performance of silicon photomultipliers, such as gain, crosstalk, and signal-to-noise ratio, are investigated.

Hunting for the gamma-ray emission from Fast Radio Burst with Fermi-LAT.
Principe G., Di Venere L., Negro M., Di Lalla N., Longo F.
University of Trieste, INFN-Trieste
Fast radio bursts (FRBs) are one of the most exciting new mysteries of astrophysics. Their origin is still unknown, but recent observations seem to link them to soft gamma repeaters and, in particular, to magnetar giant flares (MGFs). The recent detection of a MGF at GeV energies by the Fermi Large Area Telescope (LAT) motivated the search for GeV counterparts to the known FRBs. To date, none of these has a known gamma-ray counterpart. Thanks to more than 13 years of Fermi-LAT data and over 1000 FRBs, one of the largest sample created

as of today, we perform the largest and deepest search so far of high-energy emission from FRB sources, between 100 MeV and 1 TeV. In addition to the analysis involving individual FRBs on different time-scales (from few a seconds up to several years), we performed, for the first time, a stacking analysis on the whole sample of FRBs as well as a search for triplet photons in coincidence with the radio event. In this talk we present the results of our study and we discuss their implications for the predictions of gamma-ray emission from this class of sources.

Comparison between SiPMs and PMTs performance for calorimetric applications.

Alemanno F. for the DUNE Collaboration
Dipartimento di Matematica e Fisica E. De Giorgi, Università del Salento, Lecce, Italy e Istituto Nazionale di Fisica Nucleare - Sezione di Lecce, Lecce, Italy

Silicon PhotoMultipliers (SiPMs) are solid-state photodetectors with a wide range of applications in high-energy physics. SiPMs have the capability to detect from one to several thousands of photons, with good timing properties and low operating voltage, while also maintaining compactness and low costs. For the aforesaid reasons, they are becoming a promising alternative to conventional PMTs, commonly used in physics experiments throughout the last decades. In this work, the performance of SiPMs and PMTs are compared. Specifically, the purpose of this study is the definition of the calorimeter readout for the SAND detector, an element of the upcoming DUNE Experiment. The experimental setup consists of a sampling calorimeter made of lead layers and scintillating fibers, coupled with photodetectors using light guides. The readout is performed using 3 PMTs on one side and 3 distinct SiPM configurations on the opposite side, allowing the comparison between different photodetectors under various conditions. Several characteristics of PMTs and SiPMs have been studied and compared. The experimental setup, data-taking procedure and achieved results will be shown in this talk.

Ginger experiment analysis pipelines.

Castellano S. on behalf of the GINGER Collaboration
Gran Sasso Science Institute e INFN, Sezione di Pisa

Gingerino, prototype for the GINGER experiment, is a ring laser gyroscope that measures the Earth angular velocity, exploiting the Sagnac effect. Such a measurement, other than for geophysical purposes, is for fundamental physics measurements, if performed with precision and accuracy better than one part over 10^9. Ginger is a multipurpose experiment, and a few pipelines are developed for its data analysis. A geophysics dedicated pipeline is meant to be fast, with suitable filters and data decimation; the high sensitivity analysis is developed in more directions: correcting laser non-linearities, by expansion in series of the raw signal (linearization) and linear regression methods; utilizing a double Sagnac signal, which allows to improve by a factor 2 the signal-to-noise ratio, and monitoring the double signal as a feedback on data. Such methods are described; a brief overview of GINGER experiment is made.

Aula F3 - Maria Telkes **ore 15:10 – 19:30**

Sezione III
Astrofisica
Presiede: Mezzetto M. (INFN, Sezione di Padova)

Relazioni su invito

▲ **Neutrinos beyond the Standard Model.**
Pascoli S.
Università di Bologna
In the past twenty-five years, the discovery of neutrino oscillations has changed our understanding of neutrinos and proved that the Standard Model of particle physics is incomplete. We now know that neutrinos have mass and that there is leptonic mixing. An impressive progress has been made, thanks to a broad experimental programme, and most of neutrino properties have been determined with precision. In this communication, I will briefly review the current knowledge of neutrino properties and the progress that can be expected in the next decade. I will focus on the still open questions, with emphasis on the nature of neutrinos, their masses and leptonic CP violation. This information is crucial to hunt for the physics beyond the Standard Model at the origin of neutrino masses and leptonic mixing. I will review the see-saw mechanism, in its simplest realisation of type I and in its extensions. As there is no strong theoretical guidance for the new mass scale, I will briefly discuss the theoretical and observational arguments going from grand unified theory scales down to sub-GeV.

▲ **L'esperimento DUNE, stato e prospettive.**
Sirri G. per la Collaborazione DUNE
INFN Sezione di Bologna
L'esperimento DUNE, attualmente in costruzione a Fermilab e alla Sanford Underground Research Facility (SURF), è uno dei progetti di nuova generazione per la scienza dei neutrini. Il suo programma scientifico comprende la misura dei parametri dell'oscillazione dei neutrini tramite un fascio a larga banda, insieme allo studio delle astroparticelle da fonti naturali e alla fisica oltre il modello standard. Questo programma è reso possibile dalla grande massa del rivelatore (70 kt), dalla sua collocazione a 1500 m di profondità, dalla capacità superiore di imaging offerta dalla tecnologia delle TPC in argon liquido, dalla potenza senza precedenti del fascio e da un avanzato complesso di rivelatori vicini dedicati a limitare le incertezze sistematiche. In questa comunicazione sono descritte le prestazioni, lo stato della costruzione di DUNE e gli sviluppi futuri.

▲ **Hyper-Kamiokande.**
Ludovici L.
INFN, Sezione di Roma1
Hyper-Kamiokande is a multi-purpose next-generation neutrino experiment under construction in Japan. It will be the world largest underground water Cherenkov detector, with a fiducial volume 8 times larger than Super Kamiokande. The inner detector will be surrounded by more than 20000 new photo-sensors, PMTs and multi-PMTs, to detect water Cherenkov radiation with significant performance improvements. In the coming decades,

Hyper-Kamiokande will be an observatory of neutrinos from astrophysical sources, supernova burst neutrinos and supernova relic neutrinos and of rare phenomena like nucleon decay. It will also act as far detector for a long baseline experiment with the neutrino beam produced at the JPARC accelerator, currently used by T2K. A near detector suite, close to the accelerator, will characterize the beam and minimize systematic errors. In combination with the upgraded 1.3 MW neutrino beam, Hyper-Kamiokande will measure neutrino oscillation with unprecedented statistical precision, enabling the discovery of CP violation and the precise measurement of neutrino oscillation parameters. The experiment is under construction and due to start data taking in 2027.

▲ **Review of direct dark matter detection.**

Selvi M.
INFN, Sezione di Bologna

Astronomical and cosmological observations indicate that a large fraction of the energy content of the Universe is composed of Cold Dark Matter. Recently, increasingly detailed studies of the Cosmic Microwave Background anisotropies have inferred the abundance of dark matter with remarkable precision at $\sim 27\%$. One of the most favored particle candidates, under the generic name of Weakly Interacting Massive Particles (WIMPs), arises naturally in many theories beyond the Standard Model of particle physics, such as supersymmetry, universal extra dimensions, or little Higgs models. In this communication, we will review the most sensitive experimental techniques for WIMP detection, and present a summary of the results of the various experiments in the field, focussing in particular on direct detection experiments installed in underground laboratories.

▲ **Axions: Bounds and discovery opportunities.**

Carenza P. ([1]), Mirizzi A. ([2])
([1]) *Stockholm University*
([2]) *Bari University and INFN, Sezione di Bari*

Axions have been introduced in relation to the strong CP problem of the QCD and are predicted in many extensions of the Standard Model of particle physics. Depending on the actual value of their mass, axions can play an important role in cosmology, acting as cold or hot dark matter. The coupling with photons allows for axion-photon mixing in external electromagnetic fields. This effect is exploited for direct searches of axions in laboratory experiments. Axions can be searched also through astrophysical observations. Notably they can be produced in stellar cores leading to an excessive energy loss, that would alter the standard stellar evolution. Furthermore, the two-photon vertex would also induce the mixing with axions for photons emitted by distant astrophysical sources, and propagating in the large-scale cosmic magnetic fields, leading to peculiar observational signature. In this communication I will present an overview of current bounds on axions and discovery opportunities in the planned laboratory and astrophysical experiments.

Comunicazioni

● **Direct measurement of the neutrino mass: The HOLMES experiment.**

Repetto S. ([1])([3]), De Gerone M. ([1])([3]), Gallucci G. ([1])([3]), Nucciotti A. ([2])([4]), Borghesi M. ([2])([4]), Ferri E. ([2])([4]), Faverzani M. ([2])([4])
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The HOLMES experiment aims to make a direct neutrino mass measurement using calorimetric techniques with a sensitivity of the order of eV, studying the spectrum of ^{163}Ho which decays by electronic capture in an excited state of ^{163}Dy, with an endpoint of ~ 2.8 keV and half-life ~ 4570 y. To make this measurement, about 1000 cryogenic micro-calorimeters based on the Transition Edge Sensors (TES) organized in arrays where the isotope is encapsulated will be produced. The necessary activity for each detector is about 10^2 Bq. The implantation of ^{163}Ho atoms inside the detectors is a crucial point of the experiment. For this reason, an accelerator/isotope separator with a maximum accelerating potential of 50 kV was developed to implant ^{163}Ho into the micro-calorimeter arrays and simultaneously remove other radiactive isotopes (mainly ^{166m}Ho) that may be background source for the measurement. This communication will show the commissioning of the machine, calibration procedures, beam characteristics and the results obtained in the first implantation tests performed on the arrays.

Entanglement in particle physics processes.
Micciola B., Blasone M., Lambiase G., Matrella C.
Dipartimento di Fisica "E.R. Caianiello", Università di Salerno
The study of entanglement and other quantum correlations in the context of particle physics represents currently a very active research area, ranging from neutrino and kaon oscillations to spin correlations in top quarks. Another topic of interest is represented by the role of entanglement in scattering processes in the framework of Quantum Field Theory. Our group is active in this area in various directions: we shall review some recent results and focus on work in progress on the entanglement in QED processes at tree level.

The Front End electronics system for the Hyper-Kamiokande 20″ photosensor system.
Lavitola L. ([1])([3]), Ameli F. ([2]), Boiano A. ([1]), Ludovici L. ([2]), De Rosa G. ([1])([3]), Collazuol G. ([5]), Lamanna G. ([4]), Pinzino J. ([4]), Triossi A ([5]), Sozzi M. S. ([4])
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([5]) *Università di Padova, Padova, Italia*
Hyper-Kamiokande (Hyper-K) is a next-generation underground large water Cherenkov detector. Its tank will be filled with 260000 metric tons of ultra-pure water with a fiducial volume of 190 ktons, which is about 8 times larger than that of its predecessor Super-Kamiokande. In its water volume, Cherenkov light will be produced by neutrino interactions and detected by newly developed photosensors installed in a dedicated frame. Two photosensor systems will be used in Hyper-K, the 20″ Hamamatsu PMT and the multi-PMT. In this communication we will discuss the development of a novel Front End electronics system for the 20″ PMTs, that will read out 12 PMTs per board with required performance and it is realized using only discrete electronics components. Each channel has a dynamic range of 1250 photoelectrons (pe) with a resolution better than 0.1 pe at 1 pe. The maximum hit rate will be better than 1 MHz per channel and the time resolution will be better than 300 ps per hit. The system will use only 5 W for a complete 12-channels board.

Weighing quantum vacuum with Archimedes experiment.
Esposito M.

Dipartimento di Fisica, Università Federico II di Napoli, Italia

The Archimedes experiment comes within the debate around one of the longstanding problems in physics: the incompatibility between General Relativity and Quantum Theory and aims at measuring the interaction between vacuum fluctuations and gravity. Archimedes will measure the force exerted by the gravitational field on a Casimir cavity whose vacuum energy is modulated with a superconductive transition, using a balance as a small force detector. If the vacuum energy does interact with gravity a force directed upwards acts on the cavity and can be interpreted as the lack of weight of the expelled EM modes. The expected torque generated with this modulation is of the order of 10^{-13} Nm/$\sqrt{\text{Hz}}$, therefore a very sensitive beam balance has been suitably designed. A prototype has been installed and tested in the SarGrav Laboratories, with tilt sensitivity below 10^{-12} rad/$\sqrt{\text{Hz}}$ in the region 1–10 Hz, which makes it the most sensitive tiltmeter in the world, of particular interest as auxiliary sensor for gravitational waves interferometers. Currently the final setup has also been installed and the measurement of the vacuum weight is expected to be performed in 2024.

Aula F7 - Giovanna Mayr **ore 15:10 – 19:30**

Sezione V

Biofisica e fisica medica

Presiede: Sarti A. (Sapienza Università di Roma e INFN, Sezione di Roma1)

Relazioni su invito

▲ **The power of light: biomedical applications of optical radiation.**

Ciarrocchi E.

Department of Physics, University of Pisa, Pisa, Italy e INFN, Section of Pisa, Pisa, Italy

Optical imaging is a well-established imaging modality, with large use in several biomedical applications thanks to its non-invasive and non-ionizing nature, its portability and cost-effectiveness. Conventional optical imaging modalities include fluorescence and bioluminescence imaging. More recently, Cerenkov luminescence imaging has also emerged, bridging optical-sensitive devices with radiopharmaceuticals conventionally employed in clinics. The first part of this talk will provide an overview of the above-mentioned optical imaging modalities, illustrating the functioning mechanisms, the required instrumentation, and the strengths and weaknesses of each modality, especially in relation to their potential clinical translation. The second part of the presentation will be focused on Cerenkov luminescence and on its biomedical applications. Special focus will be given to its most recent and potentially groundbreaking use to measure oxygen levels in tissue during ultra-high dose rate electron radiotherapy.

▲ **3D virtual histology of paraffin-embedded human tissues using synchrotron radiation X-ray phase-contrast microtomography.**

Donato S. ([1])([2]), Agostino R.G. ([1])([3]), Arana Pena L.M. ([4])([5])([6]), Arfelli F. ([4])([5]), Brombal L. ([4])([5]), Longo R. ([4])([5]), Martellani F. ([7]), Romano A. ([7]), Rosano I. ([7]), Saccomano G. ([6])([8]), Tromba G. ([6]), Bonazza D. ([7])

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([8]) *Dipartimento di Ingegneria e Architettura, Università di Trieste, Italia*

Some tumors are characterized by invasiveness, *i.e.* the tendency of cancer cells to spread to surrounding tissues and distant organs. Currently, histology represents the gold standard in cancer diagnosis, but it provides 2D information in the selected cutting plane only, and although it is possible to produce 3D histological volumes, this is labor intensive and may introduce processing artifacts. On the contrary, X-ray–based virtual histology provides 3D visualization of different features of soft-tissue specimens which can be virtually sliced in any direction, enabling to identify the most suitable cutting plane to be selected for histological inspection and obtaining the largest cross-section of the tumor. Micro-infiltrating carcinomas of the breast, cervix, and thyroid, were acquired by phase-contrast CT (PhC-CT) at the synchrotron Elettra. PhC-CT distinguishes the morphological component of tissues, and, most importantly, enables pathologists to track the lesion in 3D, finding evidence of invasions in different locations that may be missed in histological sections. Therefore, PhC-CT could be a complementary tool to obtain additional information on morphological alterations.

▲ **Supramolecular photoactive systems for targeted antimicrobial photodynamic inactivation.**

Viappiani C. ([1]), Abbruzzetti S. ([1]), Delcanale P. ([1]), Mussini A. ([1]), Diaspro A. ([2])([3]), Bianchini P. ([1])([2])([3]), Nonell S. ([4]), Agut M. ([4]), Moreno A. ([5])
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([5]) *Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna, Brescia, Italia*

The use of photoactive molecules as light-controlled antimicrobial agents has been proposed as one of the possible strategies to tackle resistance insurgence to conventional treatments in microorganisms. Since the light-driven toxicity of the short-lived reactive oxygen species is a short-range effect (in the order of 100 nm), one of the open issues is the development of targeting systems to drive the photoactive compounds to the microorganism. We have recently proposed supramolecular photoactive systems to address the above problem. The fully biocompatible and water soluble building blocks of these compounds comprise a photoactive protein (a modified streptavidin) and a targeting protein, which is endowed with high affinity and molecular selectivity towards a molecular component located in the microorganism. Self-assembly of the building blocks is warranted by the strong streptavidin-biotin interaction. Using a variety of spectroscopic and fluorescence imaging tools, we explore the effects of assembly on photo-functional properties of the photoactive compounds, and demonstrate the capability of the supramolecular compounds in targeting and photoinactivating the microorganism.

▲ **Contribution of the Italian Space Agency to the ISS research and development program in the field of biophysics and medical physics.**

Vadrucci M., Mascetti G.
Agenzia Spaziale Italiana

The Italian Space Agency (ASI), promotes and fosters the culture of space and provides access to the International Space Station (ISS) as a space laboratory to the Italian research community. A fundamental field of study is the research on Human Health in Space and thus Biophysics (BP) and Medical Physics (MP) through the interest in space BioMedicine. The ambition of the human space exploration involves various risks. First of all the prolonged exposure of the life systems to high levels of ionizing radiation, which can increase the risk of cancer and other diseases. In this context, MP and BP studies can play a crucial role for the determination and monitoring of radiations and for the development of new tools, methods and mitigation strategies. Another extreme condition is altered gravity and therefore it is essential, in space exploration programs, to study the responses of biological systems. For the stated purpose, scientific experiments of interest to BP/MP are planned and carried out on board the ISS using astronaut crew resources. This contribution presents some recent experiments, coordinated by ASI, carried out on ISS and other are foreseen with the next space launches.

Comunicazioni

● **Vascolarizzazione coroidale mediante OCTRI.**

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([4]) *Dipartimento di Farmacia, Università degli Studi di Salerno, Fisciano ([SA]) , Italia*
L'Optical Coherence Tomography (OCT) è una tecnica di imaging non invasiva ad alta risoluzione. Lo scopo di questo lavoro è quello di ottenere dalle immagini OCT un indice dello stato di vascolarizzazione coroidale utilizzando un algoritmo di analisi immagini da noi proposto. Viene introdotto un indice chiamato CVI per trattare la vascolarizzazione coroidale. Attualmente le immagini vengono analizzate utilizzando un filtro chiamato Niblack che non consente di riprodurre correttamente le strutture anatomiche: la ricerca del massimo relativo per ogni intorno viene effettuata nell'area coroidale. Per questo motivo abbiamo proposto il nuovo algoritmo OCTRI: questo si basa sul riconoscimento dell'immagine applicato a un gruppo di pixel. È possibile selezionare nell'area coroideale l'intorno correlato ad una maggiore concentrazione di sangue: tutti gli altri punti della coroide sono confrontati con l'area selezionata. L'analisi è stata effettuata su un campione di 44 volontari, i dati ottenuti sono coerenti con i valori attesi per coroidi sane. OCTRI, riproducendo la struttura della coroide, non provoca un'eccessiva perdita di informazioni sulla reale vascolarizzazione.

● **Characterization of the physico-chemical properties of nanodiamonds as radiosensitizers under different photon-irradiation conditions.**
Aprá P. ([1]), Cemmi A. ([3]), Falconieri M. ([3]), Fratini E. ([2]), Giovannini D. ([2]), Infusino E. ([4]), Landoni V. ([4]), Mancuso M. ([2]), Mino L. ([5]), Olivero P. ([1]), Scifo J. ([3]), Sturari S. ([1]), Tomagra G. ([6]), Verna A. ([3]), Pazzaglia S. ([2]), Picollo F. ([1])
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Brain tumours are among the most difficult cancers to treat and above all medulloblastoma (MB) is the most common in children. Radiotherapy (RT) is the main treatment to kill cancer cells, but it can have disastrous neurological costs. An innovative approach to improve RT efficacy on tumours is to use radiosensitizers, sparing the surrounding tissue and reducing side effects. In this contest, nanoparticles offer unique physicochemical properties and nanodiamonds (NDs) are promising in assisting RT: the negative electron affinity of NDs with an hydrogen-terminated surface could promote the transfer of electrons and ensures a high reactivity with radical species, increasing the ND capability to locally enhance the indirect radiation damage to cells. In this work, the radiosensitizing capability of NDs of different sizes was tested *in vitro* in order to select the optimal types to be used as radiosensitizers against MB. ND uptake by human MB cells was assessed by flow cytometry and fluorescence and Raman microscopy. Then, the best photon irradiation protocols allowing the reduction of the total dose delivered in the presence of NDs were identified through cell vitality assays.

● **Monte Carlo update of ^{90}Y Voxel S-Values including Internal Bremsstrahlung and analytical model allowing the evaluation for any voxel size.**
Pistone D. ([1])([2]), Auditore L. ([1])([2]), Italiano A. ([2])([3]), Amato E. ([1])([2])([4])
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(2) *INFN, National Institute for Nuclear Physics, Section of Catania, Italy*
(3) *Department of Mathematical and Computer Science, Physical Sciences and Earth Sciences (^{MIFT}) , University of Messina, Italy*
(4) *Health Physics Unit, University Hospital "Gaetano Martino", Messina, Italy*
Voxel S-Values (VSVs) databases for 3D internal dosimetry of radionuclide therapies are available for limited numbers of voxel sizes. Additionally, it was recently highlighted that Internal Bremsstrahlung (IB) accompanying β-decay, up to now neglected in dosimetry, can give a significant contribution to the energy deposition for some β-emitters, such as ^{90}Y. In this study, updated ^{90}Y-VSVs including IB were calculated via Monte Carlo (MC) simulation, and an analytical model (AM) extending the VSV estimation to any voxel size of interest was developed. GATE MC simulations for voxelized geometries of soft tissue, of voxel sizes between 2 and 6 mm, were implemented; the central voxel was set as a homogeneous source of ^{90}Y decays and IB photons, computing VSVs with and without IB. The AM was developed through fitting procedures of the MC VSVs including IB. Comparing MC VSVs including and neglecting IB, differences between +25% and +30% were found for distances from the source beyond the maximum range of ^{90}Y β's. Comparing the VSVs from the AM with MC ones, an agreement within ±5% was found in the central voxel and photon tails, improving the accuracy with respect to previous models.

A new quantitative method to evaluate F-DOPA Pet Images in patients with extrapiramidal disease.

Cappuccio R. (1)(4), Lorenzini E. (2)(4), Paoletti R. (1)(4), Tiezzi N. (3)(4), Truzzi S. (4)
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(3) *Department of Physics, University of Pisa, Pisa*
(4) *Istituto Nazionale di Fisica Nucleare, Sezione di Pisa, Pisa*
Introduction: The aim of this study is to create and validate a new quantitative method to evaluate the concentration of tracer in basal ganglia to allow an accurate and early diagnosis of presynaptic dopaminergic neuronal damage. *Material and Methods*: We used a multiple 3D-Convolutional-Neural-Network model followed by a typical ANN (Artificial Neural Network) 3-layers stadium for final classification, to extract characterizing features from PET-slices and classify them. We trained the network on 121 F-DOPA exams of patients with movement disorders. Scoring of the network is performed on 25% (31 exams) of reshuffled-per-each-epoch training set. Final testing is executed on a set of 17 exams. *Results*: The confusion matrix analysis conducted on 31 exams scoring-set showed 14 TP, 16 TN and 1 FN that is an accuracy of 97% and a sensitivity of 93% with a classification error of 3%. The calculated AUC value was 0.989. The results obtained are largely encouraging in continuing tests of these new quantitative methods in imaging analysis. The follow-up of patients in the next two years will allow us to consolidate ANN results, basing on a well-defined set of normal cases.

Space radiobiology with the AMS detector cosmic rays measurements.

Guracho A.N. (1), Bartoloni A. (1), Strigari L. (1)(2), Paolani G. (1)(2), Santoro M. (1)(2), Della Gala G. (1)(2), Strolin S. (1)(2)
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(2) *Azienda Ospedaliero-Universitaria di Bologna, Italy*
Space radiobiology is an interdisciplinary science that examines the biological effects of ionizing radiation on humans involved in aerospace missions. The knowledge of the risk assessment of the health hazard related to human space exploration is crucial to reducing damages

induced to astronauts from Galactic Cosmic Rays (GCRs) and sun-generated radiation. GCRs have been identified as one of the primary sources of radiation exposure in space. In this context, one of the most crucial open problems is the contribution to carcinogenesis due to the effects on the cells directly and not directly irradiated, indicated as Target Effects (TEs) and Non-Target Effects (NTEs), respectively. This talk will report the status of the research on this topic at the INFN Roma Sapienza Alpha Magnetic Spectrometer (AMS) research group, where is in progress an extensive study about the risk evaluation of the NTEs that the GCRs radiation will imply when added to the TE. A theoretical framework is presented for TP-induced NTEs modelling, ready to be used with the GCRs data collected from the AMS02 detector measuring with great accuracy since 2011.

MR spectroscopy in the bone marrow and muscle for osteoporosis and osteoarthritis biomarkers identification.

Maiuro A. ([1])([2]), Mattioli D. ([2]), Manenti G. ([3]), Tarantino U. ([3]), Capuani S. ([1])([2])
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Since osteoporosis and osteoarthritis involve the whole musculoskeletal system, we investigated the human femur's bone marrow and vastus lateralis muscle using 1H-MRS in 19 osteoporotic, 20 osteoarthritic, and 15 healthy subjects to find biomarkers for osteoporosis and/or osteoarthritis. Spectra were acquired at 3 T and elaborated using LCmodel to obtain the quantification of bone marrow fatty acids and muscle metabolites. Kruskal-Wallis test with multiple comparison corrections was performed. I09-fat and cr28-creatine resonances were higher in osteoporotic than in healthy muscles. L53 in the femur's neck was higher in the healthy than in the osteoporotic group. L16 in the femur's head was higher in the healthy than in the osteoarthritic group. Water resonance was higher in the whole femur for the osteoarthritic group whereas the fat content and the total lipid content were lower in the osteoarthritic than in the other groups. These results suggest higher unsaturated fatty acids in bone marrow of healthy compared to the osteoporotic. In conclusion, the quantification of fatty acids in bones and muscles may provide biomarkers for the early diagnosis of osteoporosis and osteoarthritis.

Kurtosis MRI for endometrial cancer evaluation: clusterization and validation with histopathology.

Maiuro A. ([1])([2]), Di Stadio F. ([2]), Palombo M. ([3]), Satta S. ([4]), Perniola G. ([4]), Palaia I. ([4]), Pernazza A. ([4]), Della Rocca C. ([4]), Catalano C. ([4]), Manganaro L. ([4]), Capuani S. ([1])([2])
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Since histology is a partial and invasive diagnostic tool, we tested the potential of Diffusion Kurtosis Imaging (DKI) in Endometrial Carcinoma (EC) diagnosis. 18 volunteers with EC and 20 healthy women were enrolled. EC subjects were also investigated with histological examination. Diffusion-weighted images (DWI) were acquired at 3 T using six different b-values $= 500, 800, 1000, 1500, 2000, 2500$ s/mm^2. Kurtosis parameters (K and the diffusion D) were evaluated in the tumor (T) and peritumor areas (PT) in EC subjects and in normal

tissues (H) in healthy patients. Kruskal-Wallis test with multiple comparison correction and Cohen's d test were performed. A k-means clustering was computed on each ROI to estimate different diffusive compartments in tissues. The mean K and D and their variances were calculated on each cluster. K was higher in PT and T than in H, especially in G1 tumors, reflecting the tumoral tissues' complexity. D was higher in H than in T, due to the increased cell density in EC. Clusters showed great variabilities in K variance in T and PT. In conclusion, K reflects specific characteristics of tumoral tissues that could optimize the diagnosis and prognosis of EC.

Optimization of the production of ^{152,155,161}Tb with ^{nat}Dy(p,x) and ^{159}Tb(p,x) nuclear reactions.

Confalonieri L. ([1])([2]), Bolchini F. C. ([1])([2]), Colucci M. ([1])([2]), Haddad F. ([3]), Nigron E. ([3]), Groppi F. ([1])([2]), Manenti S. ([1])([2])
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([2]) *INFN, Sezione di Milano, Milano, Italy*
([3]) *GIP ARRONAX, Saint-Herblain, Nantes, France*

Some of the terbium radioisotopes have recently been proposed in nuclear medicine due to their characteristics: ^{149}Tb is an alpha and beta$^+$ emitter making it a candidate for radiotherapy and PET, ^{152}Tb is a multiple beta$^+$ emitter, therefore a candidate for PET, ^{155}Tb is promising for SPECT due to its gamma emissions, and ^{161}Tb emits both beta- particles and Auger electrons that can be used for Auger therapy. We studied the possibility to produce high specific activity ^{155}Tb after the decay of ^{155}Dy produced via ^{nat}Dy(p,x) and ^{159}Tb(p,x) reactions. Moreover, the possibility to produce ^{152}Tb and ^{161}Tb with ^{nat}Dy(p,x) reactions was investigated. The targets were irradiated at the GIP ARRONAX cyclotron (Saint-Herblain, FR) using the stacked foils technique with a proton beam of energy between 35 and 65 MeV. The measurement of the activity was done at LASA Laboratory (Segrate, IT) using high-resolution gamma spectrometry. We present the measured cross-sections in comparison with previous experimental results present in literature and theoretical simulations. Furthermore, thick target yield and radionuclide purity were computed to determine the feasibility of the production process.

Exploiting alpha particle induced reaction to produce terbium theranostic radioisotopes: cross-section determination up to 70 MeV.

Colucci M. ([1])([2]), Nigron E. ([3]), Guertin A. ([3])([4]), Gibertini E. ([5]), Bolchini F.C. ([1])([2]), Confalonieri L. ([1])([2]), Magagnin L. ([5]), Haddad F. ([3])([4]), Groppi F. ([1])([2]), Manenti S. ([1])([2])
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([5]) *Department of Chemistry, Materials and Chemical Engineering "Giulio Natta", Politecnico di Milano, Milan, Italy*

Most of the radionuclides used in nuclear medicine are produced via reactions induced by neutrons in nuclear reactors or by light charged particles (p or d). The use of α particles only finds limited applications due to two principal drawbacks: a lower production yield because of their short range in the target, and the limited availability of α particles beams accelerators. However, their use brings advantages including the easier radiochemical separation of the product, the atomic number of which can be two units higher than the target material. This is particularly true for radiolanthanides, the radiochemical separation of which is difficult. In this work we discuss the possibility to produce the theranostic terbium radioisotopes using

alpha particle induced reactions on natural gadolinium targets and natural europium (III) oxide targets. The cross-sections have been determined using the stacked-foils technique and compared with theoretical simulations and with previous studies, when available. The energetic range up to 70 MeV allows to produce the Tb radioisotopes that are farther from the valley of stability in the nuclide chart, like ^{149}Tb and ^{152}Tb.

Aula F5 - Hildred Blewett **ore 15:10 – 19:30**

Sezione VI
Fisica applicata, acceleratori e beni culturali
Presiede: Ruberto C. (Università di Firenze e INFN, Sezione di Firenze)

Relazioni su invito

▲ **Macroscopic FT-IR mapping for the in situ study of pictorial materials: Technological advances and applications.**
Pronti L., Romani M., Cestelli Guidi M.
INFN, Laboratori Nazionali di Frascati, Frascati, Italia
The characterization of pictorial materials *in situ* is a crucial issue for authentication, restoration and conservation purposes. In recent years, the trend in the development of instrumentations, dedicated to cultural heritage field, is to convert point-by-point techniques into imaging devices with the aim of simultaneously obtaining the spectral features of the materials and their location on the investigated areas. In this perspective, Macroscopic FT-IR mapping represents a good technique to detect the distribution of inorganic (sulphates, carbonates, silicates, etc.) and organic materials (binders, varnishes, degradation products, etc.) on painted surfaces. Here, we present the macroscopic FT-IR scanner for *in situ* analyses developed during the ARTEMISIA project (ARTificial intelligence Extended-Multispectral Imaging Scanner for In-situ Artwork analysis) funded by Lazio Region (Italy) in the contest of DTC Excellence Centre for Cultural Heritage. This technology has been applied on several paintings with the aim of supporting restoration treatments and of investigating the palette of some artists.

▲ **Discovering a textual layout in the unrolled carbonized papyri from Herculaneum by the new highly sensitive MA-XRF scanner developed at ISPC-CNR.**
Caliri C. ([1])([2]), Busacca A. ([3]), Fatuzzo C.G. ([1]), Pavone D.P. ([1]), Ravan E.L. ([1])([4]), Preisler Z. ([1]), Miliani C. ([1]), Ranocchia G. ([5]), Romano F.P. ([1])([2])
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([4]) *Sapienza, University of Rome, Rome, Italy*
([5]) *University of Pisa, Pisa, Italy*
In the last decade, the XRAYLab group of ISPC-CNR in Catania has introduced several technological innovations for the Macro X-Ray Fluorescence Imaging technique (MA-XRF), enabling new analytical possibilities in the non-invasive investigation of tangible cultural heritage. In this communication, we present a novel mobile MA-XRF scanner based on a 3D array of six SDDs operated in parallel and arranged in a compact hodoscopic geometry. The new 6-detector configuration allows us to enhance the overall chemical sensitivity of the technique, rivaling the one available in one-detector set-up of XRF beamlines at synchrotrons. Recently, our MA-XRF scanner was used for the investigation of the unrolled carbonized papyri of Herculaneum in the framework of the ERC project Greek Schools. The application of the new highly sensitive technique allowed us to reveal for the first time the existence of a textual layout drawn by the scribes with Pb-based ruling lines, confirming what was known up to today only from historical sources.

Comunicazioni

AR-XRF for the analysis of Cultural Heritage samples.
Orsilli J. ([1]), Migliori A. ([2]), Padilla Alvarez R. ([2]), Martini M. ([1]), Galli A. ([1])
([1]) *Università degli Studi di Milano-Bicocca, Dipartimento di Scienza dei Materiali, Milano, Italy*
([2]) *Nuclear Science and Instrumentation Laboratory, International Atomic Energy Agency-IAEA Laboratories, Seibersdorf, Austria*
XRF is a well-established technique for the non-invasive analysis of Cultural Heritage artifacts. However, this technique can retrieve information about the whole volume investigated, which can be hundreds of micrometers thick. Thus, the information regarding the different layers composing the sample cannot be inferred. Between the different set-ups and analytical methods that can be employed to retrieve this information, Angle Resolved-XRF is one of the easiest and cheapest to implement in a laboratory system. This technique employs the relation between the path length crossed by the fluorescence and primary radiation and the angles of detection and irradiation. The continuous change of geometry, thus, changes the fluorescence intensity according to the sample structure and composition. In this communication, indeed, we will show how Angle Resolved-XRF can be efficiently employed to infer the composition and thickness of different layers in metallic and ceramic materials, comparing the data collected at different angles of irradiation and detection, with those calculated with Sherman's equation, and considering the different possible phenomena affecting the intensity profiles.

The role of weak hydroxyl bonds and their erase in RHX dating technique.
Maspero F., Panzeri L., Galli A., Martini M.
Dipartimento di Scienza dei Materiali, Università degli Studi Milano-Bicocca, Italia e Centro Universitario di Datazioni e Archeometria Milano-Bicocca, Università degli Studi Milano-Bicocca, Italia
Rehydroxylation (RHX) dating has been proposed as a chronometric tool for use on fired-clay archaeological ceramics and bricks. It represents the chemical recombination of ceramic structure with environmental moisture. The related expansion and mass gain vary as 4th root of the time. The estimated RHX age is the ratio between the mass gain and the mass gain rate to the 4th power. The mass gain rate varies with the temperature, the mineralogy, the maximum firing temperature and the duration of firing. The main parameters of this technique have been studied in earlier works, highlighting the strengths and weaknesses of the method: the temperatures at which the analysis is performed are of critical importance. This communication gives experimental evidence of the importance of the first drying step, and that an amount of chemisorbed water can remain in the ceramic structure even after the 110 °C drying step and also demonstrates that a too-high drying temperature starts to remove RHX water. The behaviour of the measured mass *vs.* drying temperature is shown. A dating attempt on well-dated material with a modified procedure is presented.

Fission-track dating of obsidian samples form Lipari Neolithic settlements.
Bonizzoni L., Donini C., Guglielmetti A.
Dipartimento di Fisica "Aldo Pontremoli", Università degli Studi di Milano, Italia
Fission-track dating is a radiometric technique that can be used for uranium-bearing minerals and glasses. The spontaneous nuclear fission of ^{238}U creates damage trails, the fission tracks, whose density represents a measure of the time over which tracks accumulate. One of materials datable with FTD is obsidian, a naturally volcanic glass. In the Neolithic period, it was used to produce chipped tools and its trade played an important role in the Mediterranean area; currently, it is of particular interest for tracing prehistoric trading patterns. The

present work is part of a wider project aimed at studying the connection between obsidian flows on the island of Lipari and Neolithic populations on the Aeolian archipelago, in the frame of a collaboration between the department of physics of the University of Milan and Parco Archeologico delle Isole Eolie, Museo Luigi Bernabò Brea. The project outputs will give a general vision of both archaeological and volcanological aspects through the stratigraphic and radiometric dating of eruptions which produced obsidian, in relationship with the first phases of the human settlements and row material exploitation.

Tecniche di imaging a supporto del restauro di una scultura marmorea della facciata della chiesa del Gesù Nuovo di Napoli.

Paturzo M. ([1]), Rippa M. ([1]), Pagliarulo V. ([1]), Saltarelli C. ([2]), Vigorito M.R. ([2])
([1]) *Istituto di Scienze Applicate e Sistemi Intelligenti del CNR, Pozzuoli, NA, Italia*
([2]) *Università degli Studi Suor Orsola Benincasa, Napoli, Italia*

Lo studio si è concentrato su una scultura marmorea, raffigurante un angelo che indica lo stemma dei Gesuiti, posto a decorazione del portale centrale della chiesa del Gesù Nuovo di Napoli. Le tecniche ottiche non distruttive e non invasive utilizzate sono state la termografia e la scansione 3D. Le acquisizioni effettuate tramite le suddette tecniche di indagine sono state eseguite prima e dopo l'intervento di restauro sulla scultura marmorea, consistente nel consolidamento di alcune zone disgregate e dell'intera superficie erosa e nella rimozione delle croste nere e dei biodeteriogeni, presenti in varie aree della scultura. Il restauro è stato eseguito utilizzando prodotti sostenibili, atossici per l'operatore e a basso impatto ambientale. Le immagini termografiche forniscono una mappa dell'omogeneità strutturale delle aree investigate, misurando la risposta termica che risulta alterata nelle aree superficiali in cui si localizzano i prodotti di degrado (croste e/o patine biologiche). La scansione 3D invece permette di ottenere un modello 3D dell'intera scultura e misurare eventuali variazioni strutturali dovute all'intervento di restauro su scala millimetrica.

Caratterizzazione della collezione di ambre del museo di Lentini (Siracusa).

Galvagno R. ([1]), Amico R. ([2]), Fiorino F. ([1]), Gueli A.M. ([1]), Guzzardi L. ([2]), Scaccianoce G. ([3]), Stella G. ([1]), Politi G. ([1])
([1]) *Dipartimento di Fisica e Astronomia "Ettore Majorana", Università degli Studi di Catania, Italia*
([2]) *Parco Archeologico di Lentini, Siracusa, Italia*
([3]) *Collezionista privato, Catania, Italia*

L'ambra è una sostanza organica fossile derivata dalla trasformazione della resina di alberi con conseguente diverso grado di maturazione. Il tipo di ambra più comune in Europa è la succinite, nota anche come "ambra baltica" per la sua origine geografica. Un altro tipo di ambra è la simetite proveniente dalle sponde del fiume Simeto in Sicilia. Il Museo Archeologico di Lentini possiede una collezione di ambre provenienti dalla necropoli di S. Eligio il cui uso va dall'età del bronzo all'età del rame. La collaborazione tra il Parco Archeologico di Lentini e l'Università di Catania ha permesso uno studio volto a risolvere i problemi legati all'origine e alla provenienza di alcuni manufatti in ambra oggetto di studio. I campioni sono stati analizzati con spettrometria Raman e spettrofotometria a contatto. I risultati sono confrontati con quelli di ambre di origine nota da una collezione privata, notando una correlazione tra i dati ottenuti e alcune caratteristiche delle ambre, come lo stato di degrado e di maturazione. Lo studio è anche rilevante dal punto di vista metodologico per l'utilizzo di tecniche colorimetriche a campioni di ambra, materiale di grande interesse archeologico.

How to detect traces of Ink on paper using FTIR: A new perspective in faded manuscript.

Franchi M. ([1]), Cedola A. ([2])
([1]) *Dipartimento di Scienze di Base e Applicate all'Ingegneria, Sapienza Università di Roma*
([2]) *CNR-NANOTEC, Roma*

Ancient manuscripts often show discoloration of the text and thus are only partially legible. The spectroscopic techniques can help to identify the traces left by the inks in order to read the text, to characterize the materials and to understand the causes of deterioration. We present here a study to test the sensibility of FTIR in detecting ink traces at different levels of fading. For this purpose, we simulated the discoloration of inks due to natural deterioration by using different dilution of inks. We used laboratory phantom samples consisting of pure cellulose paper (Whatman paper) on which iron gall and carbon-based inks were laid down. The results will be used for testing machine learning algorithms for automatic text recognition. Once the approach has been developed, it will be applied to the fragments of manuscript discovered in Santi Quattro Coronati Complex (Rome, Italy).

Color specification: Comparison between contact and remote measurement methodologies.

Incardona A., Paladini G., Stella G., Gueli A.M.
Departement of Physics and Astronomy "Ettore Majorana", University of Catania, Italy

A methodological study regarding color specification through both contact and distance techniques is presented. The principal aim is the evaluation of chromatic differences obtained by the two methods varying the experimental parameters. The results obtained for cardboard cubes of seven hues, red (R), green (G), blue (B), yellow (Y), black (K), white (W) and grey (Gy), starting from Spectral Reflectance Factor (SRF) considering CIELAB coordinates, are presented. The color differences were evaluated through the ΔE values. The study was performed using a spectrophotometer and a spectroradiometer for, respectively, contact and remote measurements under different experimental conditions. Different illuminants (D65, A and F11), two different 2° and 10° standard observers were selected and, for contact spectrophotometer, also the measurement area was changed selecting SAV and MAV conditions related to, respectively, regions with diameter equal to 6 mm and 13 mm. The results obtained provide novel and useful insights into the behavior of the color coordinates according to the chosen experimental conditions.

Aula F2 - Ginestra Giovene Amaldi **ore 15:10 – 19:30**

Sezione VII
Didattica e storia della fisica
Presiede: Montalbano V. (Università di Siena)

Relazioni su invito

▲ **Insegnare didattica della fisica a scienze della formazione primaria: il modello MEPS.**
Michelini M.
Università di Udine, Udine, Italia
Dal 2000 è attivo in molti atenei il corso di laurea in scienze della formazione primaria con l'insegnamento di 9 cfu di Didattica della Fisica e Laboratorio. Si tratta di una grande opportunità e di una sfida per molti motivi: gli studenti sono in genere con scarsa preparazione e motivazione in campo scientifico, le classi sono numerose (intorno al centinaio di studenti) ed il compito è formare una figura professionale. La ricerca didattica ci ha offerto, soprattutto dal 1998, una ricca letteratura sulla formazione degli insegnanti, ma le indicazioni parziali di ricerca non bastano per un percorso organico che costruisca quella professionalità docente che mette in grado l'insegnante di creare ambienti di apprendimento per l'educazione scientifica. Una sperimentazione didattica di 22 anni ha permesso la messa a punto di un modello che integra attività Metaculturali, Esperienziali, Progettuali e Situate (MEPS) che ha dato buoni risultati.

▲ **Il rapporto tra geometria e fisica nell'insegnamento della fisica e della matematica. Opportunità ed esperienze didattiche a scuola e all'università.**
Balzano E.
Dipartimento di Fisica "E. Pancini", Università di Napoli Federico II, Napoli, Italia
Non sempre nella didattica a scuola e all'università si coglie l'opportunità di lavorare allo sviluppo di competenze integrate di fisica e di matematica e in particolare della geometria. In Italia la geometria (in particolare quella dello spazio) è largamente trascurata a scuola. Ciò provoca danni allo sviluppo cognitivo e genera difficoltà nella comprensione dei concetti scientifici, difficoltà che si riscontrano anche nei corsi universitari. Nell'intervento si riflette sul modo di favorire lo sviluppo del pensiero spaziale nella scuola di base. Partendo da alcune riflessioni sui rapporti tra geometria, fisica e realtà si presentano attività che sperimentiamo da anni e che, concentrandosi sulla modellazione geometrica dei fenomeni fisici, consentono di sviluppare competenze sia in fisica sia sugli aspetti formali della geometria. Un'attenzione particolare nelle proposte è dedicata alle trasformazioni geometriche, agli invarianti e alla possibilità di definire geometrie diverse.

▲ **Exhibit interattivi e congegni realizzati con Arduino per un approccio esperienziale alla questione energetica ed ambientale.**
Cerreta P., Favale V.
Associazione ScienzaViva, Centro della Scienza, Calitri, AV, Italia
La transizione ecologica, con la sua attualità, sta via via riorientando il quadro di riferimento concettuale con il quale siamo soliti presentare i fenomeni della nostra mostra interattiva "Le ruote quadrate". Ora, pur non rinunciando a stupire il visitatore, coi nostri exhibit miriamo

sempre più a coinvolgerlo sull'utilità di apprendere nozioni scientifiche degli argomenti scottanti che riguardano il mondo che ci circonda e lo sviluppo sostenibile di cui tanto si parla. Offriamo, dunque, e specialmente ai ragazzi, una nuova lettura di ciò che le nostre varie apparecchiature sono in grado di mostrare, soffermandoci intanto con maggior cura sugli aspetti basilari della produzione di energia elettrica e sull'effetto serra. Di recente, abbiamo aggiunto ad esse anche una cospicua collezione di congegni da noi realizzati con Arduino, semplici e poco costosi, i quali, richiamando con tecnologia moderna le varie esigenze del presente, costituiscono un bel complemento esperienziale degli exhibit da noi precedentemente allestiti.

Comunicazioni

Gli strumenti antichi di fisica: come proporli e come attualizzarli.

Franchini L.

Associazione Amici di Città della Scienza, Napoli, Italia

Gli strumenti antichi di fisica possono essere un notevole arricchimento della didattica: raccontano la storia dell'istituzione che li ospita e ispirano esperimenti, filmati e letture di alto contenuto culturale. Sono molte le istituzioni come musei, scuole ed università che li conservano ed espongono in Italia e all'estero. Le collezioni, che conosciamo, contengono apparecchi di fisica che si adoperavano come strumenti di misura o per realizzare esperimenti dimostrativi dalla cattedra. È possibile oggi insegnare la fisica utilizzando strumenti antichi, nel caso si abbia la fortuna di trovarsi in una struttura che li conserva, ma bisogna proteggerli da incaute manipolazioni. Per farli apprezzare è necessario renderli fruibili utilizzando anche i nuovi linguaggi di comunicazione. Ciò si può ottenere con le seguenti attività: 1) Riconoscere negli strumenti i progenitori della attuale tecnologia. 2) Studiare filmati (molti si trovano in rete) in cui sono messi in funzione strumenti del passato. 3) Realizzarne modelli con materiale della vita di tutti i giorni. 4) Metterli in funzione una tantum. 5) Leggere brani letterari in cui gli strumenti sono protagonisti.

"Quanto" conta la storia!

Mosca S. ([1]), Parisi M. ([1]), Del Monte R. ([2]), Marino A. ([1])([3])

([1]) *CNR-INO, Istituto Nazionale di Ottica, Pozzuoli, NA, Italia*

([2]) *Centro Musei delle Scienze Naturali e Fisiche, Università "Federico II", Napoli, Italia*

([3]) *CNR-ISASI, Istituto di Scienze Applicate e Sistemi Intelligenti, Dipartimento di Fisica "E. Pancini", Università "Federico II", Napoli, Italia*

La meccanica quantistica, pilastro della fisica moderna, ha per anni sconvolto gli stessi fisici che hanno contribuito ad elaborarne i principi fondamentali. Lunghi dibattiti e paradossi hanno reso difficili da accettare, nonostante il loro fascino, aspetti complessi come la sovrapposizione degli stati e il fenomeno dell'entanglement. Quest'anno gli istituti INO, ISASI e SPIN del CNR e l'Università degli Studi di Napoli Federico II hanno scelto il Museo di Fisica dell'Ateneo napoletano, per celebrare, nell'ambito delle "Italian Quantum Weeks", il World Quantum Day e allestire la mostra "Dire l'indicibile". Presentare agli studenti il percorso che ha portato alla dimostrazione sperimentale della violazione delle diseguaglianze di Bell e l'impatto sulle tecnologie di frontiera, in un luogo che conteneva in sé la storia della fisica, ci ha condotto ad alcune importanti riflessioni. In particolare in questo lavoro ci proponiamo di rispondere alla seguente domanda: l'osservazione e l'uso degli apparati sperimentali del passato, può aiutare a comprendere il percorso concettuale che ha condotto all'elaborazione della meccanica quantistica come la conosciamo oggi?

ISOradioLAb: un progetto educativo sulla radioattività ambientale nelle scuole delle piccole isole.

Groppi F. ([3])([4]), Ambrosino F. ([1])([2]), Colucci M. ([3])([4]), La Verde G. ([1])([2]), Pugliese M. ([1])([2])
([1]) *INFN, Sezione di Napoli, Napoli, Italia*
([2]) *Dipartimento di Fisica "E. Pancini", Università "Federico II", Napoli, Italia*
([3]) *Dipartimento di Fisica, Università degli Studi di Milano, Milano, Italia*
([4]) *LASA, Università degli Studi di Milano e INFN-Milano, Segrate, MI, Italia*

ISOradioLAb è un'iniziativa dell'Istituto Nazionale di Fisica Nucleare (INFN) che mira a sensibilizzare la popolazione delle isole minori italiane sulla radioattività naturale partendo dai più giovani. ISOradioLAb, infatti, coinvolge gli studenti e le studentesse delle scuole superiori nella misurazione della concentrazione di attività radon indoor nelle loro scuole e in altri edifici, offrendo loro l'opportunità di sperimentare la vita di un ricercatore, conducendo esperimenti e condividendo le loro scoperte con i loro coetanei. L'approccio enfatizza l'apprendimento pratico e la condivisione delle conoscenze. Il progetto prevede anche la distribuzione di questionari per valutare la conoscenza del radon e la percezione del rischio ad esso associato. ISOradioLAb, rispetto al più ampio RadioLAB, coinvolge studenti di territori spesso sfavoriti per via della posizione geografica. Questo contributo fornisce un resoconto delle attività svolte durante i primi anni del progetto dalle sezioni INFN di Milano e di Napoli, concentrandosi sul caso di Lampedusa e Linosa (AG), discute l'analisi dei questionari e i risultati ottenuti utilizzando i rilevatori passivi CR-39 ed elettreti.

RadioLab: un progetto didattico tra divulgazione e scienza.

La Verde G. ([1])([2]), Ambrosino F. ([1])([2]), Ragosta M. ([3]), Pugliese M. ([1])([2])
([1]) *INFN, Sezione di Napoli, Napoli, Italia*
([2]) *Dipartimento di Fisica "E. Pancini", Università di Napoli "Federico II", Napoli, Italia*
([3]) *Scuola di Ingegneria, Università della Basilicata, Potenza, Italia*

RadioLab è una delle attività di divulgazione scientifica dell'Istituto Nazionale di Fisica Nucleare (INFN) sul monitoraggio e valutazione dell'esposizione al gas radon. L'approccio didattico interdisciplinare promuove lo sviluppo di competenze trasversali, adottando integralmente le linee guida didattiche europee; inoltre il lavoro di gruppo è un'occasione per socializzare, interagire e includere. La fisica viene "fatta" dagli studenti, coinvolgendo anche gli insegnanti e declinandosi infine come un'attività di citizen science. Attraverso RadioLab la sezione di Napoli ha raccolto ed elaborato dati riguardanti misure di radon indoor in 68 scuole svolte negli ultimi 6 anni in tutto il territorio Campano, interessando 636 aule, 143 uffici e 173 spazi comuni. I risultati ottenuti sono stati validati dalla sovrapponibilità con i dati di caratterizzazione geologica e la mappa potenziale di gas radon indoor oggetto di pubblicazioni scientifiche. Pertanto è stato raggiunto un duplice obiettivo: educare gli studenti al rigore della ricerca e contribuire a fornire dati scientificamente validi per la caratterizzazione radiologica del territorio.

MoCRiS: an experiment with high school students on measuring the rate of cosmic rays during the flight of a weather balloon up the stratosphere.

Domenico L. ([1])([4])([5]), Schioppa M. ([3])([4])([5]), Bocci V. ([2])([5]), Iacoangeli F. ([2])([5]), Brosio A. ([2])([5]), Arcani M. ([6]), Passarelli D. ([3]), on behalf of the OCRA Collaboration ([1])
([1]) *Liceo Scientifico "Stefano Patrizi", Cariati, CS, Italia*
([2]) *INFN, Sezione di Roma I, Roma, Italia*
([3]) *Dipartimento di Fisica, Università della Calabria, Rende, CS, Italia*
([4]) *INFN, Laboratori Nazionali di Frascati, Gruppo Collegato di Cosenza, Cosenza, Italia*

([5]) *Collaborazione OCRA-INFN*
([6]) *Astroparticle Detectors Array Laboratory, GAT Astronomical Center, Tradate, VA, Italy*
High school students and teachers perform Victor Hesse's experiment in a modern key on the origin of the natural ionizing radiation in the air that surrounds us constantly. The "Stefano Patrizi" scientific high school of Cariati, in collaboration with the INFN-OCRA, the physics department of the University of Calabria, ADA Project and the ABProject, have trained the students to perform measurements of the natural ionizing radiation using modern particle detectors in the school laboratory. The same detectors are then put into the payload of the balloon and left to rise to stratosphere. The students follow the launch like engineers and physicists during a real space launch. They control the data flow that the GSM installed in the spacecraft transmits to the ground and checks the quality of these data. The spacecraft also carries a weather station, an ozone sensor, a UV radiation sensor, and three GPSs. This presentation describes the preparation phases and the first results of this launch, as well as the tests presented to the students to study their satisfaction.

Da due circonferenze alla deviazione luminosa minima prodotta da un prisma.

Catone P.
ITIS-LS "F. Giordani", Caserta, Italia
Mi soffermo sulla convenienza didattica di usare due circonferenze per interpretare la rifrazione della luce e applico questo procedimento per spiegare geometricamente l'argomento intricato della deviazione luminosa minima fornita da un prisma, rielaborando alcuni miei precedenti lavori. Per ottenere la condizione di deviazione minima in modo tradizionale, occorre utilizzare l'analisi matematica, la legge di Snell più volte e le disequazioni trigonometriche. La procedura è lontana dall'obiettivo di avere una deduzione palese del risultato; inoltre, non ho trovato nella letteratura didattica consultata una versione agevole del problema. Poiché il fenomeno è facilmente riproducibile, sorge spontanea la curiosità di capirlo. I tentativi analitici da me esperiti, per trasformare le dimostrazioni tradizionali in spiegazioni didattiche, conducevano a metodi ancora più complessi. Servendomi di due circonferenze e dell'angolo del prisma e applicando alcuni teoremi di geometria, traspare chiaramente la condizione di deviazione minima. Il metodo diventa più coinvolgente e spedito se viene implementato col software Geogebra.

La meccanica del muscolo.

Romano P.
Dipartimento di Scienze e Tecnologie, Università del Sannio, Benevento, Italia
In questo lavoro verrà presentato il muscolo dal punto di vista meccanico, mettendo in evidenza i principali risultati esistenti in letteratura sull'approccio fisico al comportamento muscolare. La tematica costituisce un possibile argomento di studio interdisciplinare per studenti di scuola superiore, per estendere i metodi quantitativi propri della fisica ad altri ambiti disciplinari. Lo studio della meccanica muscolare può essere condotto seguendo un approccio classico in cui il muscolo viene rappresentato attraverso un modello funzionale basato su un'analogia meccanica. Le principali grandezze meccaniche considerate sono la forza sviluppata e la velocità di accorciamento. La relazione forza-velocità per l'elemento contrattile del muscolo fu evidenziata da Hill attraverso un'equazione di andamento iperbolico che rappresenta la risposta meccanica del muscolo e a tutt'oggi rimane un'eccellente descrizione fenomenologica del comportamento di tutti i tipi di fibre muscolari. La forma di tale relazione ha importanti implicazioni per differenti aspetti della fisiologia muscolare e può essere rilevante per altri campi, come ad esempio lo sviluppo della robotica.

La successione di Fibonacci nel laboratorio di fisica con molle e resistenze elettriche.

Capone R. ([1]), Adesso M. G. ([2]), Fiore O. ([3])
([1]) *Università di Bari "Aldo Moro", Bari, Italia*
([2]) *Liceo Scientifico "G. Da Procida", Salerno, Italia*
([3]) *Liceo "P. E. Imbriani", Avellino, Italia*

In questo lavoro, è presentata un'attività didattica interdisciplinare laboratoriale sperimentata con la metodologia "hands-on" con studenti delle scuole superiori. L'attività incentrata sulla scoperta della sequenza di Fibonacci e del numero di Fidia. Gli studenti, in laboratorio, hanno costruito, con un breadboard, un circuito elettrico bidimensionale, costituito da un numero finito di celle elementari, ogni cella costituita da resistenze in serie e in parallelo di valore uguale. Hanno misurato, di volta in volta, la resistenza equivalente tra due nodi del sistema. Successivamente, essi hanno costruito un sistema analogo a quello precedente costituito da molle con costanti elastiche uguali. Di volta in volta hanno misurato la costante elastica equivalente. Hanno verificato le stesse proprietà simmetriche riscoprendo il numero di Fidia, in entrambe le situazioni sperimentali. Gli studenti hanno sviluppato conoscenza dei contenuti, pensiero critico, collaborazione, creatività e capacità comunicative. L'esperienza pratica ha aumentato la motivazione e la partecipazione degli studenti, rendendoli più coinvolti nel processo educativo.

Il Lesson Study interdisciplinare per lo sviluppo professionale del docente: un laboratorio incrociato di matematica e fisica.

Capone R. ([1]), Adesso M. G. ([2]), Fiore O. ([3])
([1]) *Università di Bari "Aldo Moro", Bari, Italia*
([2]) *Liceo Scientifico "G. Da Procida", Salerno, Italia*
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Questa ricerca è focalizzata sul Lesson Study interdisciplinare, come strumento per favorire lo sviluppo professionale del docente. Il Lesson Study ha le sue radici in Giappone, dove è praticato dagli insegnanti da più di 140 anni e diffuso oggi in tutto il mondo, anche in Italia. La sperimentazione didattica è stata condotta con docenti di matematica e fisica della scuola secondaria di II grado in classi seconde ed è stata incentrata sul topic delle trasformazioni energetiche. L'insegnamento è stato condotto seguendo il modello IBSE delle 5E. La lente teorica utilizzata per analizzare i dati è l'idea di semisfera di Lotman rivisitata nel contesto educativo. Sembra che i processi di insegnamento collaborativo rendano gli insegnanti consapevoli che l'asimmetria tra le discipline può essere un motore di conoscenza e che attraversando alcuni confini essi possono contribuire a formare gli studenti come cittadini del 21mo secolo. Inoltre, sembra che questi processi possano anche migliorare l'azione didattica delle singole discipline.

Introduzione dell'analisi dei dati con Python nei corsi di laboratorio di fisica.

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In tutte le discipline scientifiche, la quantità di dati disponibile è in rapido aumento e sono necessari strumenti avanzati per gestirli e analizzarli. È quindi sempre più necessario promuovere il prima possibile "competenze computazionali" nel curriculum di fisica. Un ambiente favorevole per questo scopo sono i corsi introduttivi di laboratorio. In questa presentazione descriveremo come abbiamo introdotto l'analisi dei dati con Python nel corso di laboratorio del primo anno dell'Università di Potsdam in Germania, senza alterare significativamente la struttura del corso esistente. Le potenzialità dei Jupyter Notebooks sono state sfruttate per

creare un'introduzione a Python per il calcolo scientifico con esercizi ed esempi sui metodi di analisi dati e con applicazioni a esperimenti di fisica. Gli studenti hanno utilizzato questi materiali in maniera indipendente e collaborativa e successivamente applicato le competenze acquisite negli esperimenti successivi. L'efficacia dell'intervento è stata valutata sulla base di studi empirici quantitativi. Essi forniscono informazioni sulla preparazione iniziale degli studenti, sulle aspettative e sull'apprendimento.

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