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EPM 2024 Call

Orientation paper: suggestions to develop research projects in testing and measurements for the upcoming European Partnership on Metrology (EPM) Calls in 2024

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In the webpages of the digital strategy of the European Commission, in particular in the pages entitled “Shaping Europe’s digital future” there is a Quantum dedicated page [1] where it is explicitly said that:

“In the next few years, quantum technologies will make it possible to do things that simply cannot be done today. With quantum, we will be able to look far beneath the ground or under the sea and perform complex computational tasks, like modeling biomolecular and chemical reactions, that the most powerful supercomputers cannot currently manage. Quantum will help us send sensitive information safely to anywhere, and diagnose diseases more quickly and accurately by looking inside cells. In other words, quantum will solve problems that would take even today’s fastest computers hundreds of days, if not years.
[...]
A whole generation of new technologies with the potential for far-reaching economic and societal impact is starting to emerge in the main quantum application domains: quantum computing and simulation, quantum communication, and quantum sensing and metrology. Some are already in development, while many others will be developed in the coming years. The potential of quantum is huge, and all major world regions are investing heavily in this highly strategic field. The EU’s Digital Decade strategy [2] therefore aims for Europe to have its first supercomputer with quantum acceleration by 2025, paving the way to being at the cutting edge of quantum capabilities by 2030. The European Chips Act [3] also includes measures to foster the low-cost, high-volume manufacturing of quantum chips in the EU, so that they can power a whole range of innovative quantum devices.”

In particular, regarding Quantum Computer it states that

“As part of the European High Performance Computing Joint Undertaking (EuroHPC JU) [4], the Commission is now planning to build state-of-the-art pilot quantum computers. These computers will act as accelerators interconnected with the Joint Undertaking’s supercomputers [5], forming 'hybrid' machines that blend the best of quantum and classical computing technologies.
[..]
This will be the first step towards the deployment of a European quantum computing infrastructure, which will be accessible to European users from science and industry via the cloud on a non-commercial basis. This infrastructure will be dedicated to accelerating the creation of new knowledge and solutions to global societal challenges. Thanks to its massive computing capacity, it will address complex simulation and optimisation problems, especially in materials development, drug discovery, weather forecasting, transportation and other real-world problems of high importance to industry and society. ”

Regarding Quantum Communication it states that
"Since June 2019, all 27 EU Member States have signed the EuroQCI Declaration [6], agreeing to work together, with the Commission and with the support of the European Space Agency, towards the development of a quantum communication infrastructure covering the whole EU (EuroQCI)."

The CEN/CLC Standardization Roadmap on Quantum Technologies [7] identified two major domains of applications and related standardization needs in the field of metrology for quantum technologies. On one side, the novel applications enabled by Quantum Technologies (e.g.: traceability and realization of SI base units outside of NMIs or novel and improved sensing and metrology devices). On the other side, the characterization, benchmarking, and evaluation for reliable Quantum Technologies, being reliable testing and traceable measurements a fundamental prerequisite for development and commercial usage of QT devices.

The purpose of the present document, in agreement with EMN-Q mission to support competitiveness and innovation of the emerging European Quantum Industry by metrology science, services, and knowledge transfer, is to identify the priorities related to the development of quantum technologies at the European Level. The EMN-Q is ideally positioned to identify the gaps in measurement capabilities and standards necessary for advancing quantum technologies and to collaboratively develop the solutions necessary to serve the rapidly growing needs of stakeholders. This orientation paper is particularly focused on the Calls Digital Transformation and Normative.

This orientation paper is based on three main elements:

- the European Digital Strategy
- The EMN-Q strategic Research Agenda
- The "Standardization Roadmap on Quantum Technologies written by the CEN-CENELEC Focus Group on Quantum Technologies (FGQT)" (Document FGQT Q04 Release 1 – March 2023) [7, 8];

- **Quantum Communication (QC) and Quantum Key Distribution (QKD)**

  QC enhances classical communications or enables new possibilities through the transmission/distribution of quantum states. To transmit quantum states it is not only necessary to have the ability to create and manipulate quantum states, but also to provide quantum channels to distribute these states. **QKD** enables a highly secure generation and distribution of cryptographic keys that does not rely on the unbreakability of mathematical algorithms. QKD represents a resource against a cryptanalytic attack by a quantum computer and operates in the single-photon regime by distributing secret digital keys over optical links.

  Key categories of quantum technology devices and components in the **QC/QKD** fields that are prioritized with regards to standardization needs include:

  - **QKD transmitter and receiver modules**

  - **QT Subsystems for QKD** (e.g. Quantum Channels, Quantum Random Number Generators and for a significant classes of Quantum Communication systems, Single Photon Sources, Single Photon Detectors, Coherent Quantum Receivers, etc.)

  - **QKD protocols** (e.g., Twin-Field QKD, Measurement-Device-Independent QKD, etc) **and Implementation Security for QKD** (e.g. SI-traceable measurements at the single- photon level to characterise complete QKD systems, QKD internal subsystems and components, and countermeasures to hacking attacks)

- **Enabling Technologies for Quantum Computing:**

  - **Ion traps** as a fundamental building block for a wide range of applications over several subfields of QT: quantum computation, quantum simulation, and quantum metrology. Standardization and measurement needs are fabrication parameters, electrical operating factors, vacuum compatibility, heating rates for cryogenic traps, etc.

  - Microfabricated chip-scale **superconducting circuits.** Important examples include chips for quantum computing but also quantum sensors for magnetometry, and single photon detection. The required standardization tasks are: e.g., fabrication process and design rules, measured metrics and their information exchange, and packaging of superconducting circuits.

  - **Traveling wave parametric amplifiers (TWPA),** typically in the frequency range of approximately 2 GHz to 10 GHz. Based either on the non-linearity provided by Josephson-junctions or the kinetic inductance of disordered superconductors these devices constitute the building block for quantum computer but also first amplifier of the amplification chain for the readout wiring of superconducting qubits or microwave kinetic inductance detectors (MKID) for radio-astronomy. Typical parameters that need to be specified are: e.g., technical drawings, connectors, pump frequency and power, magnetic field and current bias. Crucial measurements that need to be defined are e.g., power gain, saturation power, bandwidth, gain ripple and added noise.

References

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[4] https://digital-strategy.ec.europa.eu/en/policies/high-performance-computing-joint-undertaking

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[6] https://digital-strategy.ec.europa.eu/en/news/future-quantum-eu-countries-plan-ultra-secure-communication-network

[7] https://www.cencenelec.eu/media/CEN-CENELEC/AreasOfWork/CEN-CENELEC_Topics/Quantum%20technologies/Documentation%20and%20Materials/fgqt_q04_standardizationroadmapquantumtechnologies_release1.pdf

[8] https://www.cencenelec.eu/areas-of-work/cen-cenelec-topics/quantum-technologies/