A new modified Jamin interferometer for the IMGC-02 transportable rise-and-fall absolute gravimeter

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Introduction

Measurements of gravitational acceleration are performed by absolute gravimeters, traceable to the units of length and time through their primary standards. For this purpose, INRiM developed a transportable ballistic rise-and-fall absolute gravimeter, the IMGC-02. It uses laser interferometry to measure the symmetrical free rising and falling motion of a test mass in the gravity field. In this work the future improvement of the current interferometer is described.

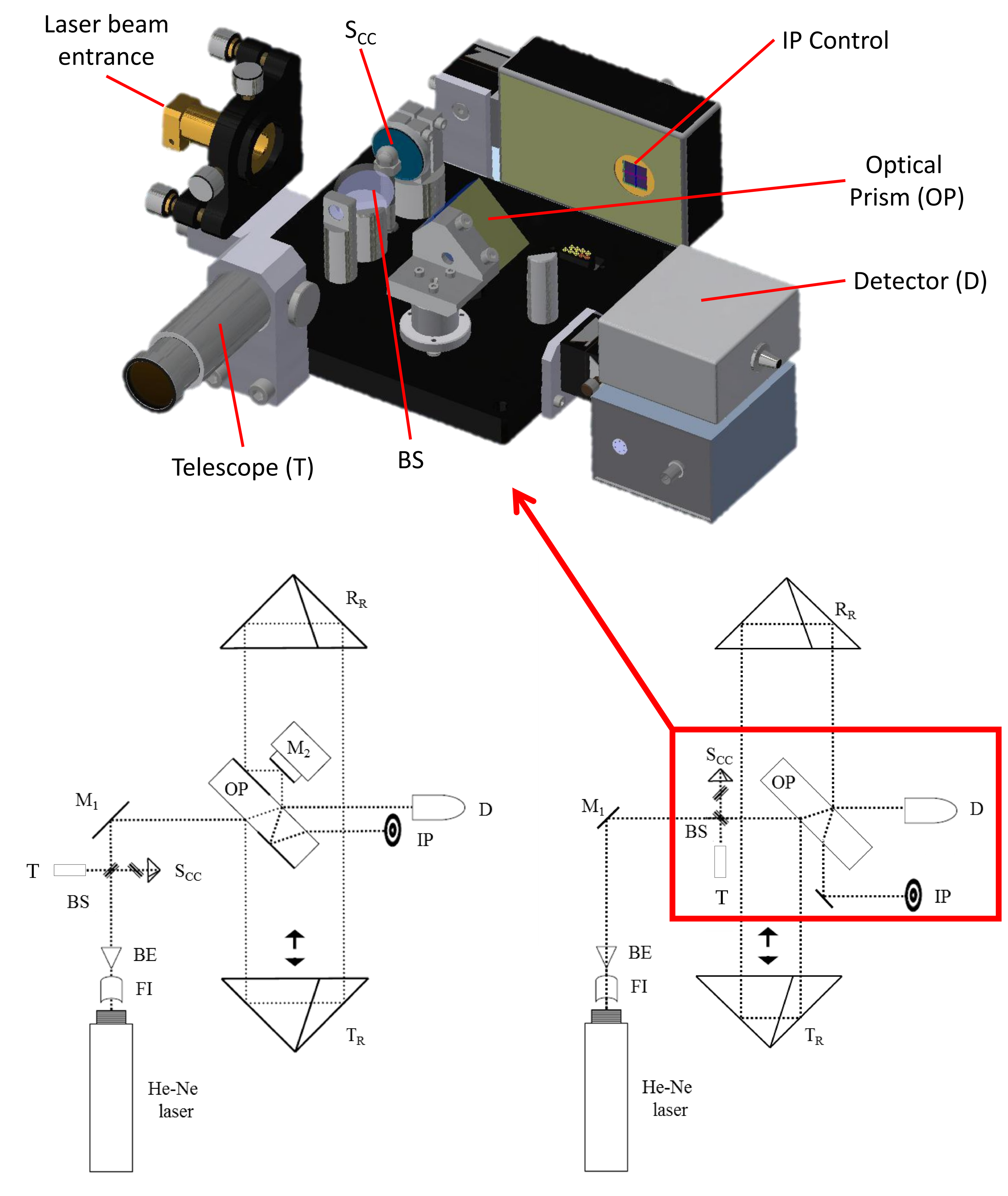
The current modified Mach-Zehnder interferometer

The light emitted by the He-Ne laser ($\lambda \approx 633$ nm) passes through an optical Faraday isolator FI which works as a back talk preventer. After the Faraday isolator the beam is enlarged to 2 mm spot size by a beam expander BE and proceeds vertically toward a beamsplitter BS. One of the beams proceeds horizontally toward a small cubic corner prism S_{CC} used to observe the vertical orientation of the beam through a telescope T. The other beam, vertically directed, is deviated by a moveable mirror M_1 which can be rotated around two axes to adjust the direction of the shifting arm of the interferometer to the true vertical. These elements are needed to check the verticality of the laser beam. Afterwards the beam enters horizontally into the optical prism OP situated beneath the reference retroreflector corner-cube R_R. The OP has been designed in such a way that half is a reflecting mirror and half is a beamsplitter. The incident light is divided into two beams by the first beam splitter. One of the beams, which represents the fixed arm of the interferometer, proceeds horizontally, strikes the second beamsplitter and goes straight toward the detector D. The second beam generated by the first beamsplitter travels vertically down to the test-mass's retroreflector corner-cube T_R and forms the shifting arm of the interferometer. It is reflected back to R_R and strikes the movable mirror M_2 after being reflected by the prism. The adjustment of M_2 allows the beams to recombine at the second beam splitter of OP. The interference fringe causes cyclic variations in intensity with regard to the change in the difference between the two optical path lengths at every half wavelength displacement of the test-mass retroreflector T_R. The detector D converts the output light of the interferometer to an electric signal. The test-mass trajectory is measured by timing this electric signal. Since the recombining beams have to be coaxial in order to avoid distortions on the laser interference fringes, the angular position of the mirror M_2 has to be adjusted every time before the measurement and has to be monitored during the measurement. The alignment is achieved by rotating the mirror M_2 around its two axes through a piezoelectric PZT-driven tilter actuator. Unfortunately, this operation entails practical problems, is highly time-consuming and has to be performed before and during the measurement session.

The new modified Jamin interferometer

For this reason a new modified Jamin interferometer has been devised. Such system is similar to the modified Mach-Zehnder interferometer except that the two beams directly recombine on the optical prism OP, thus the movable mirror M_2 is removed. The alignment of the recombined beams is possible by just shifting the reference corner-cube retroreflector R_R along the horizontal plane.

Fig. 1 - 3D-Scheme of the new modified Jamin interferometer on the horizontal plane



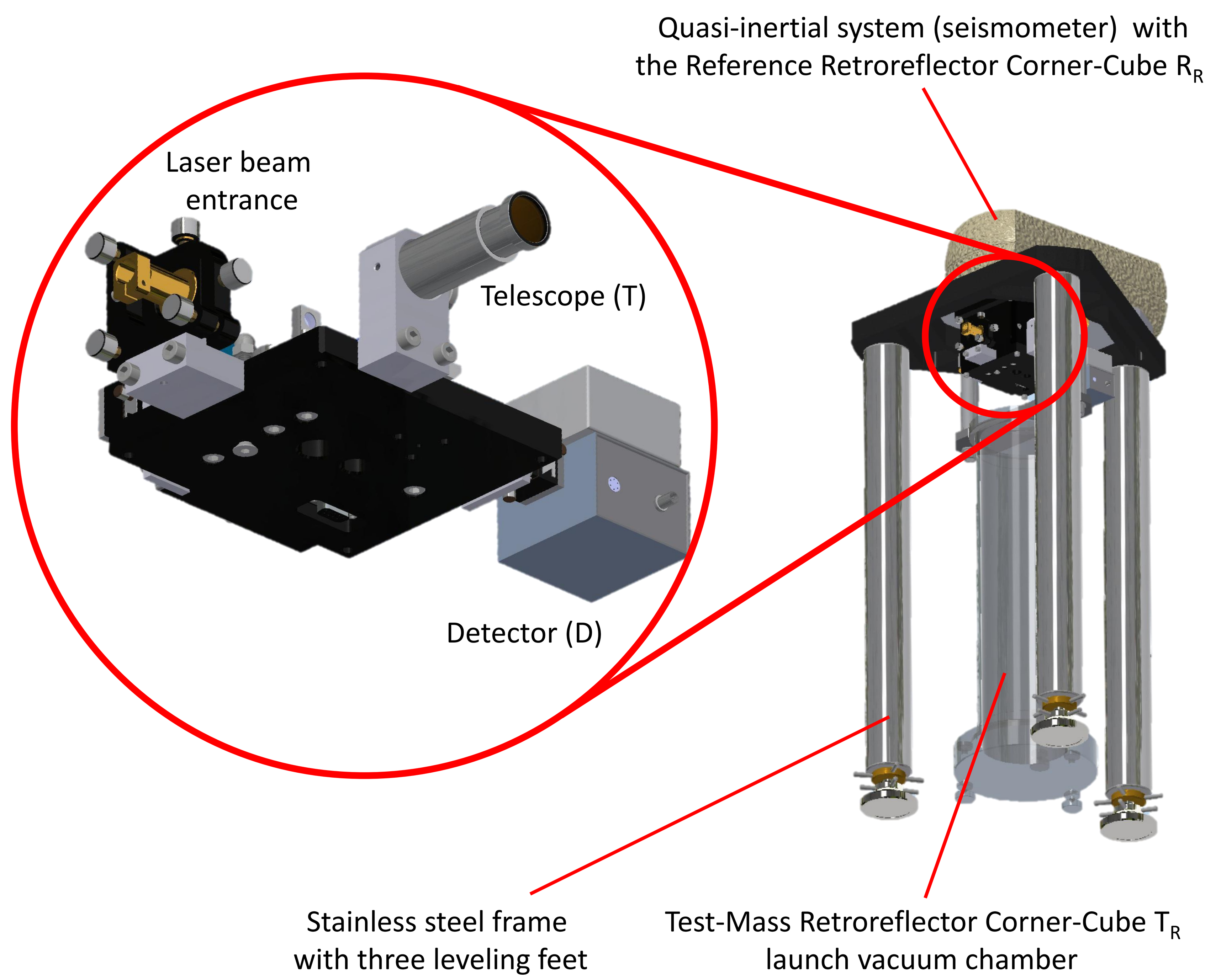
The modified Mach-Zehnder interferometer **The new modified Jamin interferometer**

OP=Optical Prism
BE=Beam Expander
FI=Faraday Isolator
BS=Beam Splitter
D=Detector
T=Telescope
IP=Interference Pattern Control
M=Mirror
R_R=Reference Retroreflector Corner-Cube
T_R=Test-Mass Retroreflector Corner-Cube
S_{CC}=Small Corner-Cube

Main advantages

- Simpler and faster alignment of the two beams
- Better stability in time, unless negligible Abbe errors due to the misalignment of the two upper and lower corner-cube retroreflectors, and the divergence of the retroreflectors, which are simply overcome by using corner-cubes and an optical prism with angular accuracy within 1" and a flatness within $\lambda/10 \approx 60$ nm

Fig. 2 - Bottom view of the 3D-Scheme of the new modified Jamin interferometer integrated in the IMGC-02 rise-and-fall ballistic gravimeter



Conclusions

A new modified Jamin interferometer has been designed for the IMGC-02 transportable rise-and-fall absolute gravimeter. The new interferometric system guarantees more robust measurements and a faster preliminary installation of the gravimeter before the measurement.

References

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[2] Germak A, Desogus S and Origlia C, Interferometer for the IMGC rise-and-fall absolute gravimeter, Metrologia 39(5), 2002, pp 471-475.