METROLOGICAL EVALUATION OF ABSOLUTE DIFFERENTIAL GRAVIMETERS

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ABSTRACT:

Quantum gravimeters have recently become commercially available and are now capable of measuring the acceleration of gravity with sensitivities reaching one part per billion. Achieving such accuracy requires a rigorous metrological evaluation to ensure measurement reliability and to verify performance at this extreme sensitivity level. This work extends decades of international metrology research on atom-based gravimeters to a new generation of instruments: quantum gravity gradiometers.

The study focuses on a comprehensive metrological assessment of the DQG, an industrial-grade mobile gravity gradiometer developed by Exail. Since the DQG and MIGA, which is a static and high-performance gradiometer designed at LP2N for future gravitational-wave detection, share similar atom-interferometric principles, several of the systematic effects analyzed in this work are also relevant for this project.

Systematic effects investigated so far include the influence of magnetic fields, together with an in-depth study of parasitic transitions occurring at low magnetic field, as well as self-gravity. The next effect under evaluation is the two-photon light shift, which is expected to play an important role in high-precision differential measurements.

In addition to laboratory studies, a field measurement campaign was conducted in Lisbon with the DQG in the framework of the Fiqugs project. The instrument demonstrated excellent performance as it successfully detected the presence of an underground aqueduct beneath the historical city center, confirming the suitability of quantum gradiometers for non-invasive subsurface exploration such as cavity detection. This campaign also served to benchmark the DQG sensitivity in preparation for a newly developed smaller version of the instrument that will be mounted on a wheeled robotic platform to facilitate future field surveys.