



CARIOQA Pathfinder Mission Development towards Future Quantum Space Gravimetry Missions

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For over two decades, satellite gravimetry missions have been measuring the Earth's gravity field globally providing valuable observations for geosciences. Successor missions are already in development to extend this time series. Future objectives include achieving higher spatial and temporal resolutions of gravity field products as well as enhancing the measurement accuracy, currently constraint by, among other aspects, instrument performances. While some adaptations have already been made or are foreseen for the upcoming MAGIC constellation, a significant advancement could be made by replacing or combining the commonly used electrostatic accelerometer on board the satellites with quantum-based sensors to overcome currently existing limitations.

Before launching a dedicated quantum space gravimetry mission, however, the application of a cold atom interferometer as an accelerometer in space needs to be demonstrated to reach the necessary technology readiness level. This shall be achieved by a quantum pathfinder mission which is prepared in the framework of the Cold Atom Rubidium Interferometer in Orbit for Quantum Accelerometer (CARIOQA) project in the Horizon Europe funding programme. The ongoing Pathfinder Mission Preparation (CARIOQA-PMP) project involves developing an engineering model as well as a comprehensive study on the potential scientific outcome of both the quantum pathfinder mission and a future quantum space gravimetry mission. In parallel to PMP, a Phase A (CARIOQA-PHA) study defining requirements on the mission, instrument and satellite, and assessing the overall feasibility of a quantum space gravimetry pathfinder mission is nearing its completion.

This contribution will present simulated gravity field solutions considering the CARIOQA pathfinder mission, a single satellite in high-low satellite-to-satellite tracking mode, and possible future quantum space gravimetry missions consisting of a satellite constellation utilizing low-low satellite-to-satellite tracking. Closed-loop simulations were carried out to assess the benefits of a quantum-based accelerometer compared to the commonly used electrostatic one and to identify remaining challenges.

CARIOQA-PMP is a joint European project, including experts in satellite instrument development (Airbus, Exail SAS, TELETET, LEONARDO), quantum sensing (LUH, SYRTE, LP2N, LCAR, ONERA,

FORTH), space geodesy, Earth sciences and users of gravity field data (LUH, TUM, POLIMI, DTU), as well as in impact maximisation and assessment (PRAXI Network/FORTH, G.A.C. Group), coordinated by the French and German space agencies CNES and DLR under CNES lead. The CARIOQA-PHA project includes key partners (CNES, DLR, ADS-F, ADS-G, FORTH) from the CARIOQA-PMP consortium, plus a new industrial partner for the mission analysis (GMV).

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