Quantum Gases in Space for Fundamental Physics and Earth Observation

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Space-borne quantum technologies and more particularly atom-based devices are announcing a new era of strategic, intense space exploitation. Indeed, space offers a unique environment characterized by low-noise and low-gravity necessary for a wide spectrum of applications ranging from time and frequency transfer to Earth observation and the exploration of fundamental laws of physics.

In this contribution, we report about two recent mission concepts based on the use of quantum-gas sensors. The first is the satellite mission Space-Time Explorer and QUantum Equivalence Principle Space Test (STE-QUEST), currently a phase-2 candidate for the M7 launch opportunity of the European Space Agency's science programme. STE-QUEST, with its dual-species atom interferometer operating over tens of seconds, will address some of the most fundamental and puzzling questions of physics by testing the universality of free fall with an accuracy better than one part in 10^{-17}, searching for different types of Ultra-Light Dark Matter (ULDM) and testing the foundations of quantum mechanics. The second mission concept is the CARIOQA (Cold Atom Rubidium Interferometer in Orbit for Quantum Accelerometry) pathfinder recently selected by the European Commission. It will pave the way for a space geodesy mission using atom accelerometers to map the temporal variations of the Earth's gravity field.

The essential bricks of such missions have already been demonstrated in pioneering space implementations of atom optics experiments on sounding rockets (German Aerospace Agency, DLR) or aboard the International Space Station (NASA). An update about relevant aspects of these realizations will also be presented.