DAMOP19-2019-020057

Abstract for an Invited Paper
for the DAMOP19 Meeting of
the American Physical Society

**Airborne and underground matter-wave interferometers: geodesy, navigation and general relativity**[1]

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The remarkable success of atom coherent manipulation techniques has motivated competitive research and development in precision metrology. Matter-wave inertial sensors  accelerometers, gyrometers, gravimeters  based on these techniques are today at the forefront of their respective measurement classes. Atom inertial sensors provide nowadays about the best accelerometers and gravimeters and allow, for instance, to make the most precise monitoring of gravity, navigate without GPS or device precise tests of general relativity. I will present some recent advances in these fields:
1) - We operate matter-wave interferometers in the micro-gravity environment created during parabolic flights. Using two atomic species allows to verify that two massive bodies will undergo the same gravitational acceleration regardless of their mass or composition, allowing a test of the Weak Equivalence Principle (WEP). Recently, a laboratory class microgravity simulator allows to enhance these measurements with sample of ultracold atoms cooled down to nanoKelvin temperatures.
2) - Matter-wave interferometry can be used to study sub-Hertz variations of the strain tensor of space-time and gravitation. MIGA, which is currently built in France, will allow the monitoring of the evolution of the gravitational field at unprecedented sensitivity, which will be exploited both for geophysical studies and for Gravitational Waves (GWs) detection. In the initial instrument configuration, standard atom interferometry techniques will be adopted, which will bring to a peak strain sensitivity of $2 \times 10^{-13}/\sqrt{\text{Hz}}$ at 2 Hz. This demonstrator will enable to study the techniques to push further the sensitivity for the future development of gravitational wave detectors based on large scale atom interferometers.
3) - Inertial navigation systems determine the position of a moving vehicle by continuously measuring its acceleration and rotation rate, and subsequently integrating the equations of motion. These systems are limited by slow drifts, on the order of 10 $\mu$g which, in the absence of aiding sensors such as satellite navigation systems, leads to large position errors. Ultrastable cold-atom interferometers offer a promising when hybridizing stable matter-wave based inertial sensor with a classical accelerometer. By using correlations between the quantum and classical devices to track the bias drift of the latter and form a hybrid sensor, an optimal estimate of the bias with a stability of 10 ng after 11 h of integration has been demontrated thus offering new prospect for the development of quantum based navigation systems.

[1]This work is supported by ANR, DGA, CNES, ESA and the national Equipex program. PB aknowledges a "chaire d'excellence" from Region Nouvelle Aquitaine.