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Talk Title: Quantum sensors with colds atoms: fundamental physics and applications from underground to space

Abstract: 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 all 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 or to device precise tests of the weak equivalence principle (WEP). I present here some recent advances in these fields:

The outstanding developments of laser-cooling techniques and related technologies allowed the demonstration of an airborne matter-wave interferometers, which operated in the micro-gravity environment created during the parabolic flights of the Novespace Zero-g aircraft or in our lab-based Einstein Elevator. Using two atomic species (for instance ^{39}K and ^{87}Rb) 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 postulated by Einstein.

New concepts of matter-wave interferometry can also be used to study the low frequency variations of the strain tensor of space-time and gravitation. For instance, the MIGA instrument, which is currently built in the underground laboratory in Rustrel, 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) observations.

Figure 1. Top: the migrovavity matter-wave lab onboard the Novespace 0-G Airbus. Bottom: the galleries under Plateau d'Albion Rustel, that will host the first gravitational wave detector prototype using cold atoms.