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ABSTRACT:

Since about twenty years atom interferometers have been studied for measuring inertial forces to high precision with atoms in free fall. The use of cold atoms was key for a reduction of the size of these devices. New methods of cooling and trapping permit to perform interferometry with guided atoms which opens new perspectives for measuring forces with high spatial resolution. This thesis explored both directions by employing atoms in free fall for rotation sensing and guided atoms for testing gravity at close distances.

The CASI gyroscope is based on a double Raman interferometer with counter-propagating atomic trajectories. This work presents studies on the long term stability of the sensor and an improvement in sensitivity to rotations of one order of magnitude compared to the previous status. A sensitivity of 2×10^{-8} rad/s after an integration time of 4000 s was achieved using a post-correction technique based on a correlation of the rotation signal to the atomic sample arrival time.

The FORCA-G experiment targets to measure short range forces with high spatial resolution based on Raman interferometers using laser induced tunneling in an optical lattice. Measurements are presented showing a sensitivity to the gravitational acceleration of 2×10^{-5} $g/\sqrt{Hz}$. The resulting sensitivity after 150 s of integration will allow for a measurement of Casimir-Polder forces in 5 µm atom-surface separation with 1 % statistical uncertainty. Finally, the implementation of a coherent atomic transport based on an accelerated lattice for future short range force measurements is reported.