Applications of Large-Momentum-Transfer atom interferometry

Giulio D'Amico

Supervisors: Prof. Guglielmo M. Tino

Light-pulse atom interferometers are extremely sensitive and accurate quantum sensors for the measurement of inertial forces and for testing fundamental physics. They are largely used for applications in metrology and gravitational physics (e.g. as gravimeters and gradiometers). Furthermore important practical applications of these devices are found in geodesy, geophysics, engineering prospecting and inertial navigation. Even if the present interferometry instruments already outperform classical devices, their sensitivity has not yet reached its ultimate limit. Since the sensitivity of atom interferometers improves by increasing the momentum transferred to the atoms during the beam splitter and mirror pulses a lot of theoretical and experimental efforts have been dedicated to the development of Large Momentum Transfer (LMT) atom-optics techniques.

One of the most promising LMT techniques consists in the use of Bragg diffraction processes as atom optical elements. The interaction between an atomic wave-packet and an optical lattice generated by two counter-propagating lasers allows for a momentum transfer which scales linearly with the diffraction order excited. Furthermore Bragg diffraction provides a separation of the interferometric paths only in the external atomic degrees of freedom, while the internal atomic state remains unperturbed. This makes Bragg interferometers less affected by many systematic effects, like AC-Stark and Zeeman shifts.

We study the application of LMT techniques (in particular Bragg diffraction) in atom interferometers for the measurement of gravitational phenomena, and tests of fundamental physics such as tests of the equivalence principle. Part of the study is realized with the gradiometric apparatus MAGIA, present in the Physics department of the Florence University.
We also consider the application of LMT techniques for long interrogation time apparatuses (T~1 s) which further increase their measurement sensitivity to inertial forces.

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