Compensation of gravity gradients and rotations in gravitational antennas based on atom interferometry

Albert Roura[1]

[1]albert.roura@uni-ulm.de, Ulm University, Germany

Due to gravity gradients and rotations, the phase shift in atom interferometry becomes sensitive to the initial position and velocity of the atomic wave packet. This poses a major challenge for high-precision measurements, which require an extremely accurate control of these initial conditions. In the first part of the talk I will review a valuable technique based on a suitable frequency change of the intermediate laser pulse that can effectively overcome the difficulties associated with gravity gradients [1]. Moreover, the method can be combined with the use of a tip-tilt mirror to compensate the effects of rotations and non-aligned gravity gradients. It has already been successfully applied to tests of the universality of free fall [2] as well as absolute gravity-gradient measurements [3] and the determination of the gravitational constant G [3,4].

The technique can be adapted to mitigate the coupling of initial-position and -velocity jitter to gravity gradients and rotations in gravitational antennas. This will be illustrated with the example of the MIGA facility [5] and compared to other approaches involving intermediate relaunches of the atomic cloud. Finally, an alternative configuration accomplishing similar goals but applicable also to atom interferometers based on single-photon diffraction will be presented. The insensitivity to laser phase noise of this kind of interferometry makes it particularly appealing for gravitational antennas with long baselines [6] and related searches for ultralight dark-matter fields [7].

This work has been supported by the German Space Agency (DLR) with funds provided by the Federal Ministry of Economics and Energy (BMWi) under Grant No. 50WM1556 (QUANTUS IV).

[1] A. Roura, *Phys. Rev. Lett.* **118**, 160401 (2017).

[2] C. Overstreet et al., *Phys. Rev. Lett.* **120**, 183604 (2018).

[3] G. D'Amico et al., *Phys. Rev. Lett.* **119**, 253201 (2017).

[4] G. Rosi, *Metrologia.* **55**, 50 (2018).

[5] B. Canuel et al., *Sci. Rep.* **8**, 14064 (2018).

[6] P. W. Graham et al., *Phys. Rev. Lett.* **110**, 171102 (2013).

[7] A. Arvanitaki et al., *Phys. Rev. D* **97**, 075020 (2018).