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Atom-chip-based quantum gravimetry for the precise determination of absolute gravity

Sven Abend, Christian Schubert, Wolfgang Ertmer, and Ernst Rasel
Institut für Quantenoptik, Leibniz Universität Hannover, Hannover, Germany

We present a novel technique for the precise measurement of absolute local gravity with a quantum gravimeter based on an atom chip. Atom interferometry utilizes the interference of matter waves interrogated by laser light to read out inertial forces. Today's generation of these devices typically operate with test mass samples, that consists of ensembles of laser cooled atoms. Their performance is limited by the velocity spread and finite-size of the test masses that impose systematic uncertainties at the level of a few μGal [1]. Rather than laser cooled atoms we employ quantum degenerate ensembles, so called Bose-Einstein condensates [2], as ultra-sensitive probes for gravity. These sources offer unique properties that will allow to overcome the current limitations in the next generation of sensors. Furthermore, atom-chip technology offers the possibility to generate Bose-Einstein condensates in a fast and reliable way.

We present a lab-based prototype that uses the atom chip itself to retro-reflect the interrogation laser and thus serves as inertial reference inside the vacuum [3]. With this setup, it is possible to demonstrate all necessary steps to measure gravity, including the preparation of the source, spanning an interferometer as well as the detection of the output signal. All steps are pursued on a baseline of 1 cm right below the atom chip and to analyze relevant systematic effects.

In the framework of the center of excellence geoQ a next generation device is under construction at the Institut für Quantenoptik, that will target for in-field measurements. This device will feature a state-of-the-art atom-chip source with a high-flux of ultra-cold atoms at a repetition rate of 1-2 Hz [4]. The device will be characterized in cooperation with the Müller group at the Institut für Erdmessung the sensor and finally employed in a campaign to measure the Fennoscandian uplift at the level of 1 μGal.

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[1] A. Peters et al., Nature 400, 849, 1999; A. Louchet-Chauvet et al., New J. Phys. 13, 065026, 2011; C. Freier et al., J. of Phys.: Conf. Series 723, 012050, 2016; V. Schkolnik et al., Appl. Phys. B 120, 311–316 (2015).

[2] K. B. Davis et al., Phys. Rev. Lett. 74, 5202, 1995; M. H. Anderson et al., Science 269, 198, 1995; C. C. Bradley et al., Phys. Rev. Lett. 75, 1687, 1995.

[3] S. Abend et al., Phys. Rev. Lett. 117, 203003, 2016.

[4] J. Rudolph et al., New J. Phys. 17, 065001, 2015.