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High-precision gravity measurements with the mobile atom interferometer GAIN

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The atom interferometer GAIN uses interfering ensembles of laser-cooled $^{87}\mathrm{Rb}$ atoms in a fountain setup to measure local gravity. Our instrument's performance was compared to falling corner-cube and superconducting gravimeters during three measurement campaigns at geodetic observatories in Wettzell, Germany and Onsala, Sweden. In these long-term measurements, we demonstrated sensitivities better than $100\,\mathrm{nm/s^2/\sqrt{Hz}}$, a stability better than $1\,\mathrm{nm/s^2}$ [1] and an accuracy comparable with the best classical gravity sensors at the 10^{-9} level in g. We will present the results of these measurement campaigns, including a summary of "lessons learned" and a study of active and passive vibration isolation strategies.

The use of atoms as test masses opens up the possibility to implement different measurement topologies with little need for modifications of the existing apparatus. We will show preliminary results of gravity gradient measurements using two atomic samples and magnetic field mapping techniques [2] implemented into GAIN.

Finally, we will discuss recent improvements of the apparatus, including a new modularized laser system and report on our efforts towards simplified techniques for the laser-cooling of of two atomic species with a single diode laser performing fast controlled frequency jumps [3].

[1] Freier et al.Mobile quantum gravity sensor with unprecedented stability. Journal of Physics: Conference Series, 8th Symposium on Frequency Standards and Metrology 2015, 723, 12050 (2016)

[2] Hu et al. Mapping the absolute magnetic field and evaluating the quadratic Zeeman-effect-induced systematic error in an atom interferometer gravimeter, Physical Review A 96, 033414 (2017)

[3] Wiegand et al. A single-laser alternating-frequency magneto-optical trap (in preparation)