High precision gravity measurements with the mobile atom interferometer GAIN

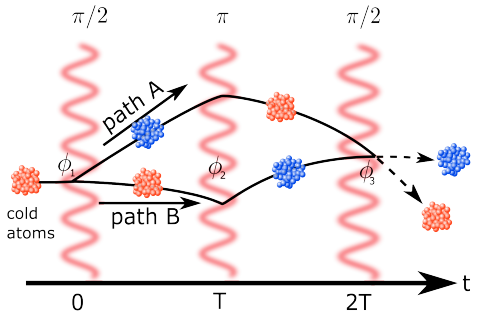
V. Schkolnik, M. Hauth, C. Freier, B. Leykauf and A. Peters
Institut für Physik
Humboldt-Universität zu Berlin
Newtonstraße 15, 12489 Berlin
e-mail: vladimir.schkolnik@physik.hu-berlin.de

Abstract

Absolute and relative gravimeters are used to observe gravity and its time dependent changes due to mass variations caused by a variety of environmental effects. State of the art spring and free-fall instruments are sometimes limited, e.g., in mobility or by instrumental effects. The most precise instruments cannot be transported easily and the most mobile instruments are affected by drift overlaying the small gravity changes important for geodesy and hydrology.

A completely new type of gravimeter based on atom interferometry will enable absolute and drift-free continuous gravity data acquisition with high precision. The Gravimetric Atom Interferometer GAIN is a mobile gravimeter based on interfering ensembles of laser cooled ^{87}Rb atoms in an atomic fountain configuration. It is specifically designed to perform high precision gravity measurements at different sites of interest.

We present our recent measurements, including the comparisons with the state-of-the-art spring gravimeter, a falling corner cube gravimeter, and a super-conducting relative gravimeter. The latter comparison is conducted at the geodetic observatory in Wettzell to demonstrate the robustness and mobility of our gravimeter. A sensitivity of $1.2 \times 10^{-8}\, g/\sqrt{\mathrm{Hz}}$ is achieved and no drift over a period of 10 days is observed. We give an overview of the main systematic effects including a new method capable of overcoming the limitation caused by wavefront aberrations to reach a targeted accuracy of $5 \times 10^{-10}\, g$.



$$\Delta\Phi = \delta\phi(0) - 2\delta\phi(T) + \delta\phi(2T) = k_{\mathrm{eff}} g T^2$$

Figure 1: The atom interferometry sequence consists of three pulses to perform splitting, inversion, and recombination of the atoms. After the final pulse, the relative population of the states is detected. It depends on the accumulated phase difference $\Delta\Phi$ between the two matter wave packets in the interferometer region and is proportional to the gravitational acceleration g.

Keywords: Atom interferometry, gravimeter

References

[1] M. Hauth, C. Freier,V. Schkolnik, A. Senger, M. Schmidt, and A. Peters, Applied Physics B 113, **1**, (2013).

[2] M. Hauth, C. Freier,V. Schkolnik, H. Wziontek, M. Schilling and A. Peters, Proceedings of the International School of Physics "Enrico Fermi", Course 188 (2014).