

Mobile accelerometers based on atom interferometry for high-precision measurements of local gravity

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Abstract

Since 1991, matter wave interferometry has been used in many laboratories for a variety of fundamental physics experiments, e.g. measurement of the fine-structure and gravity constants. However, due to the complexity of these experiments, they were confined to laboratory environments. Only in recent years efforts have been undertaken to develop mobile atom interferometers. These new sensors open up the possibility to perform on-site high-precision measurements of rotations, gravity gradients as well as absolute accelerations.

GAIN (Gravimetric Atom Interferometer) is a mobile and robust gravimeter that is being developed within the framework of the EuroQUASAR/IQS programme. It is based on interfering ensembles of laser cooled ^{87}Rb atoms in a one meter high atomic fountain configuration. With a targeted accuracy of a few parts in 10^{10} for the measurement of local gravity g this instrument will offer about an order of magnitude improvement in performance over the best currently available absolute gravimeters. Together with the capability to perform measurements directly at sites of geological interest, this opens up the possibility for a number of interesting applications: As this technology will significantly improve the precision of gravity measurements in fields such as geodesy, geophysics or seismology, our project profits from collaborations with EuroQUASAR/IQS partners in geophysical communities.

We introduce the working principle of our interferometer and give an outline of the subsystems needed for a mobile setup. Characterisations of

the most vital subsystems are given, including a rack-mounted cooling and Raman laser system, a very low-noise optical Raman laser phase lock and a highly adaptable yet mobile main vacuum chamber setup. Latest measurements of local gravity are presented and the next steps necessary to achieve full accuracy are discussed.

Secondly, we present the Space Atom Interferometry (SAI) project that investigates both experimentally and theoretically the different aspects of placing atom interferometers in space: the equipment needs, the resulting device sensitivities, and what physics might be done using such systems. For these purposes, the project brings together European institutions to share their mutual expertise and to collaborate on the construction of an atom interferometer testbed geared towards future applications in space. We give an overview of the sensors ultra-compact design and report on the status of its first completed subsystems. Finally, applications of the testbed apparatus that most closely approximate space environment conditions on earth are discussed. The SAI project is financed by ESA (contract 20578/07/NL/VJ). <http://www.physik.hu-berlin.de/qom>

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