Towards atom interferometry in microgravity

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Abstract

The research field of cold and degenerate quantum gases offers the possibility to study ideal models for a multitude of fundamental and applied problems in the quantum domain. In recent years, developments of new and versatile trap configurations, the use of various atomic species and mixtures, as well as enlarged accuracy of the applied manipulation methods drastically extended the variety of simulated quantum systems. As a consequence of these efforts atom interferometry was shown to be an appropriate candidate to perform high precision measurements, e.g. to measure inertial forces such as gravity or rotations.

Microgravity promises to substantially extend the science of degenerate quantum gases towards nowadays inaccessible regimes of low temperatures, macroscopic dimensions of coherent matter waves and longer unperturbed evolution. Utilizing this low noise environment for interferometry schemes and applications like inertial quantum sensors with high precision is one of the main goals of the QUANTUS project. As a source for coherent matter waves we use a Bose-Einstein condensate of Rubidium 87, whose ultra-long free evolution of one second in microgravity was already demonstrated at the drop tower in Bremen (ZARM). In order to realize a Mach-Zehnder interferometer we choose Bragg diffraction as a coherent beam splitting process. With this setup we will be able to measure spatial and temporal coherence in the extended parameter regime available during the free fall.

In addition we are working on the second generation apparatus, which combines an extremely compact design and extends the physics observable in microgravity. The experiment is planned to use 87Rb and 40K as degenerate Bose-Fermi mixtures in order to carry out experiments on tests of the Weak Equivalence Principle in the quantum domain. A major experimental challenge is to design a catapult capable experimental setup, which have to withstand 30g accelerations during the catapult launch. In the catapult mode we can prepare and manipulate our wave packets during 9 seconds of microgravity, which substantially increases the interrogation time and therefore the sensitivity of the interferometer.

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References

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