MICROGRAVITY SCIENCES AND PROCESSES (A2)
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MATTER WAVE INTERFEROMETRY IN MICROGRAVITY AND ITS APPLICATIONS FOR HIGH PRECISION MEASUREMENTS AND EARTH OBSERVATION

Abstract

Space-borne inertial sensors based on interferometry with ultra cold matter waves are a valuable tool for different physics missions. The spectrum of applications covers a broad area from geodesy, through gravimetry and metrology up to addressing fundamental questions in physics, as for instance testing the Einstein equivalence principle in the quantum domain. QUANTUS is a German collaboration targeting the long-term goal of studying cold quantum gases on a space platform and investigating the feasibility of matter wave sensors for precision measurements. The performance of such a device is mainly limited by the unperturbed evolution time of the wave packets in the interferometer. Here, microgravity conditions offer extremely long interrogation times and ultra low temperatures of the quantum object, which substantially increase sensitivity to levels not obtainable on Earth.

Focussing the vision of quantum sensors in space, the pioneering experiment QUANTUS has realized a Bose-Einstein condensate in microgravity at the drop tower in Bremen (ZARM). The successful observation of the free evolution for up to 1 second was a milestone towards operating dilute quantum gas experiments under extreme conditions [1]. With an advanced version of the setup we are now performing preliminary experiments with a BEC in a Mach-Zehnder interferometer composed of light pulses. Additionally we are setting up a new experimental apparatus, which is designed to operate with two atomic species simultaneously to study the weak equivalence principle.

As an important stepping stone a sounding rocket mission is planned for fall 2013. In contrast to the drop capsule based apparatus, this means even higher requirements in terms of robustness, miniaturization and redundancy. With a higher number of condensed atoms compared to the predecessor, a microgravity duration of a few minutes and large area interferometry, we intend to investigate macroscopically separated quantum objects in a so far unexplored regime. This talk summarizes our latest results in matter wave interferometry and focuses on the huge potential of atom based interferometry in the unique environment of microgravity.

The QUANTUS project is a collaboration of LU Hannover, HU Berlin, U Hamburg, U Ulm, TU Darmstadt, MPQ Munich, FBH Berlin, U Birmingham, Laboratoire Kastler Brossel Paris, DLR RY Bremen and ZARM at U Bremen. It is supported by the German Space Agency DLR with funds provided by the Federal Ministry of Economics and Technology (BMWi) under grant number DLR 50WM 1131-1137.

[1] T. van Zoest et al., Science 328 (2010)