BEC interferometry and quantum tests of the equivalence principle

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A central goal of modern physics is to test fundamental principles of nature with ever increasing precision. Atomic quantum sensors are a key-technology for the ultra-precise monitoring of accelerations and rotations. They allow for example to compare the free fall of two atomic clouds of different species, thus testing the weak equivalence principle (WEP) in the quantum domain.

In this poster, we present four projects where atom interferometers are realized to test the WEP. Two compact apparatus suited to operate in µ-gravity environments at the drop-tower in Bremen, one apparatus being built to operate on a sounding rocket and one lab based dual species atom interferometer. At the heart of the three µ-gravity experiments, atom chips are the key ingredient that allows for an unprecedented miniaturization of BEC machines. The first generation of experiments consists in a Bragg-type interferometer on a chip operated with ^{87}Rb atoms in the thermal or Bose-Einstein condensed regime. With the help of delta-kick cooling, we extend the observation of a BEC of only 10^4 atoms up to two seconds and operate an asymmetric Mach-Zehnder interferometer over 700 ms. In the second generation experiment we have developed a novel atom chip setup and a novel loading scheme that allowed us to produce Bose-Einstein condensates of a few 10^5 ^{87}Rb atoms every two seconds. Using the drop tower's catapult mode, our setup will perform dual species atom interferometry during nine seconds in free fall – times which are inaccessible for ground based devices. As a next step towards the transfer of such a system in space a chip-based atom interferometer operating on a sounding rocket is currently being built. The success of this project would mark a major advancement towards a precise measurement of the WEP with a space-born atom interferometer. Furthermore results of our lab based dual species atom interferometer will be presented. By comparing the free fall of rubidium and potassium a test of the WEP could be performed at the 10^{-7} level, which represents the first test of the WEP with simultaneously freely falling matter waves of different atomic species.

This project is supported by the German Space Agency (DLR) with funds provided by the Federal Ministry of Economics and Technology (BMWI) under grant number DLR 50 WM 0346. We thank the German Research Foundation for funding the Cluster of Excellence QUEST Centre for Quantum Engineering and Space-Time Research.