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QUANTUM GASES ABOARD THE ISS - CAPABILITIES OF THE BECCAL PROJECT

Abstract

This paper shall give a summary on the Bose Einstein Condensate – Cold Atoms Laboratory (BECCAL) payload considered for operation on board of the international space station. The current status of the ongoing activities will be presented and the foreseen capabilities of the payload outlined.

Ever since the experimental realization of the first Bose-Einstein Condensate (BEC) in 1995 [1], various experiments have been developed to study the resulting cloud of atoms. In addition, matter wave interferometry has been of rising interest as tools to investigate other physics phenomena, such as the equivalence principle. The potential of measuring small divergences of forces has led to the application of matter wave interferometers as accelerometers and gravimeters.

Atom interferometry requires the unperturbed free evolution of the cloud. In regular Bose-Einstein condensate experiments the atoms are trapped and cooled in a magneto-optical trap. To allow for free evolution the atoms have to be removed from the trap. Since atoms are subjected to gravitation the cloud will accelerated in the gravitational field. Thus, matter wave interferometry with Bose-Einstein condensates and degenerate Fermi gases benefits greatly from microgravity environments.

In small Earth-bound experiments the cloud can be accelerated upwards inside the experimental setup, effectively producing a fountain of atoms, to perform interferometry. Other options to allow unperturbed evolution, and in consequence subject the atom cloud to microgravity environments, are drop-tower experiments, parabolic flights, sounding rocket campaigns, and experiments on board the ISS or on satellites. Within the collaboration, different approaches to perform atom interferometry in microgravity are investigated. First experiments were performed using the drop-tower at ZARM [2]. Succeeding these successful campaigns, the capsule containing the atom interferometer has been adapted to fit a sounding rocket.

The first launch of an atom interferometer on board of a sounding rocket has been performed in January 2017. While this campaign is mainly aimed at the technological demonstration, further campaigns will make use of the microgravity conditions to perform atom interferometry with different atomic species.

The logical extension to these missions is the adaptation for long term operation of an atom interferometer under microgravity conditions – BECCAL. Within this contributions the capabilities of the

payload, based on the successful experiments in the drop tower and on board of the sounding rockets will be discussed.

[1] K.B. Davis et al., Phys. Rev. Lett 75, 3969(1995)

[2] T. van Zoest et al., Science 328, 1540(2010)