Paper ID: 44945
oral

IAF MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Gravity and Fundamental Physics (1)

Author: Dr. Waldemar Herr
Leibniz Universiät Hannover, Germany

Dr. Ernst Maria Rasel
Leibniz Universiät Hannover, Germany

ATOM INTERFEROMETRY FROM EARTH TO SPACE THE QUANTUS, MAIUS, AND BECCAL CONSORTIA

Abstract

Atom interferometry is widely used for measuring rotations and accelerations with applications in navigation, geodesy, and fundamental physics. In our group, a cold atom gyroscope [1] measured earth's rotation at the percent level, a dual species cold atom gravimeter performs ground-based quantum tests of Einstein's Equivalence Principle [2], and we investigate novel technologies and techniques for spaceborne implementations.

Today's inertial sensitive atom interferometry devices operate mostly with sources of laser-cooled atoms. The finite temperature and size of these sources limit the efficiency of employed beam splitters and the analysis of systematic uncertainties. These limits can be overcome by the use of ultra-cold sources such as a Bose-Einstein condensates (BEC) or in addition magnetically lensed atomic ensembles with extremely narrow velocity distributions. Usually the creation of BECs is time-consuming, but our demonstration of a compact high-flux source for the generation of BEC [3] has led to a paradigm shift in atom interferometry. BECs open up the use of high-contrast single and double Bragg diffraction, the transfer of more than 1000 $\hbar k$ by multi-photon transitions, and the utilization of matter-wave lenses to collimate the atomic ensemble in 3D to enter the picokelvin regime.

As the sensitivity in these kinds of experiments depends on the square of the free evolution time of the atomic ensemble, the extension of this time is investigated in our microgravity facilities: In the QUANTUS experiments in the drop tower Bremen [4,5] and in the MAIUS sounding rocket experiments, where the MAIUS-1 mission demonstrated the first BEC in space in January, 2017 [6].

These pioneering experiments are opening the era of maturity of matter-wave quantum optics experiments for future space borne applications, like aboard the ISS as we pursue within the US - German BECCAL consortium.

This presentation will focus on our work on BEC interferometry on earth and in space for future space borne applications, like experiments with quantum mixtures aboard the ISS and spaceborn quantum tests of Einstein's Equivalence Principle [7].

1. P. Berg et al., Phys. Rev. Lett. 114, 063002 (2015).
2. D. Schlippert, et al., Phys. Rev. Lett. 112, 203002 (2014).
3. J. Rudolph et al., New J. Phys. 17, 079601 (2015).
4. H. Müntinga et al., Phys. Rev. Lett. 110, 093602 (2013).
5. J. Rudolph et al. Micrograviy Sci. Technol. 23, 287 (2011).
6. http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-20337 (on 27.02.2018).
7. D. N. Aguilera et al., Class. Quantum Grav. 31, 115010 (2014).