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

Author: Dr. Naceur Gaaloul
Institute of Quantum Optics, Germany, gaaloul@iqo.uni-hannover.de

Prof. Claus Braxmaier
Konstanz University of Applied Sciences, Germany, braxm@htwg-konstanz.de
Dr. Thilo Schuldt
Konstanz University of Applied Sciences, Germany, tschuldt@htwg-konstanz.de
Dr. Sven Herrmann
ZARM University of Bremen, Germany, sven.herrmann@zarm.uni-bremen.de
Dr. Landragin Arnaud
Observatoire de Paris, France, Arnaud.Landragin@obspm.fr
Dr. Philippe Bouyer
Institut d'Optique, France, philippe.bouyer@institutoptique.fr
Prof. Kai Bongs
University of Birmingham, United Kingdom, k.bongs@bham.ac.uk
Prof. Achim Peters
Humboldt University of Berlin, Germany, achim.peters@physik.hu-berlin.de
Dr. Ernst Maria Rasel
Leibniz Universiät Hannover, Germany, rasel@iqo.uni-hannover.de

STE-QUEST: A SPACE-BASED EQUIVALENCE PRINCIPLE TEST USING ATOM INTERFEROMETRY

Abstract

The Space-Time Explorer and Quantum Equivalence Principle Space Test mission (STE-QUEST) was selected by ESA as one of four candidates for the M3 mission within the Cosmic Vision Program with launch in 2022. The satellite will host an atomic clock and an atom interferometer operated with the same atomic species, Rubidium-87 (87Rb). A second atom interferometer with a different isotope of the same species, Rubidium-85 (85Rb), will be operated as reference. STE-QUEST will test the far reaching consequences of Einstein's postulate and one of the most fundamental predictions of Einstein's Theory of General Relativity with high precision. It thereby searches for hints of quantum effects in gravity, contributing to the exploration of one of the current frontiers in fundamental physics. The mission will measure space-time curvature via the precise determination of gravitational time dilation, i.e. the difference in the ticking rate of the satellite's atomic clock when it is compared with a ground-based clock. At the same time, the satellite will allow for the comparison of the free propagation of coherent matter waves of 85Rb and 87Rb under the influence of the Earth's gravity with precision matter wave interferometry, striving for an accuracy of few parts in 10^{15} and beyond. The use of ultra-cold matter at quantum degeneracy will permit to go far beyond the current accuracy of quantum tests.

This presentation will focus on the STE-QUEST dual atom interferometer payload, which is based on the strong European developments in this field. The atom interferometer is measuring the differential acceleration of the two atomic Rubidium isotopes along one axis with respect to the spacecraft with a resolution of $10^{-12}\, m/s^2$. The high common mode rejection of the dual atom interferometer permits to achieve this high differential accelerational resolution despite the ambient vibrational noise of the

spacecraft. A high sensitive accelerometer on board will enable to correlate the atom interferometric measurement with the occurring vibrations for testing the performance of the atom interferometer. For achieving an optimal suppression of common-mode-noise, which accords to basically all possible sources of disturbance, the two atomic species are simultaneously prepared, coherently manipulated and detected with optimally overlapped atomic clouds of the two species. The atom interferometer concept as well as the baseline design will be presented.