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Author: Mr. Hauke Müntinga
ZARM University of Bremen, Germany

Dr. Sven Herrmann
ZARM University of Bremen, Germany
Prof. Claus Lämmerzahl
ZARM Fab GmbH, Germany
Dr. QUANTUS Team
Germany

QUANTUS-1: TOWARDS A SYMMETRIC MATTER WAVE INTERFEROMETER FOR SPACE APPLICATIONS

Abstract

Ultracold atoms have proven to be a promising candidate as a source for coherent matter waves to be utilized in precision tests of fundamental physical principals, especially the Universality of Free Fall.

In a Matter Wave Interferometer based on Bragg diffraction, two counterpropagating laser beams form a moving optical lattice which can transfer momentum to the atoms, thus acting as a beam splitter or mirror for matter waves. While in a ground based lab, gravity breaks the symmetry of the system, in microgravity, the system becomes symmetric, and Double Diffraction occurs [1]: The atoms are at rest and interact with both beam pairs, thus three momentum states are coupled. This suppresses systematic effects from laser phase noise and makes Double Diffraction an interesting tool to investigate for precision measurements.

In this talk, we report on first ground based experiments carried out in the QUANTUS-I apparatus [2]: The laser beams are aligned perpendicular to gravity, and with a delta-kick cooled BEC a Mach-Zehnder type interferometer is created. A small gravitational acceleration is introduced resulting in a phase shift in the interferometer signal. We demonstrate scalability of the system by observing interference fringes with first order, sequential first order, and second order Bragg pulses. These experiments constitute an important step towards a test of the Weak Equivalence Principle with ultracold atoms in space, as proposed e.g. by the STE-QUEST consortium [3,4].

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[1] Giese et al., PRA 88, 053608

[2] Müntinga, Ahlers, Krutzik, Wenzlawski et al., PRL 110, 093602

[3] Aguilera, D. et al. "STE-QUEST - Test of the Universality of Free Fall Using Cold Atom Interferometry." arXiv:1312.5980, December 20, 2013. http://arxiv.org/abs/1312.5980.

[4] Schubert, C. et al. "Differential Atom Interferometry with ^{87}Rb and ^{85}Rb for Testing the UFF in STE-QUEST." arXiv:1312.5963, December 20, 2013. http://arxiv.org/abs/1312.5963.