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REALISTIC 3D SIMULATIONS OF BRAGG BEAM SPLITTERS FOR MATTER WAVE INTERFEROMETRY UNDER MICROGRAVITY

Abstract

Atomic beam splitters are a central component of matter wave interferometers, which provide the opportunity of high-precision rotation and acceleration sensing. Therefore, microgravity is of high relevance. Potential applications range from tests of fundamental physics to inertial navigation. In the QUANTUS (Quantum Gases in Microgravity) free-fall experiments atom interferometry is the central method as well and within the MAIUS (Matter-Wave Interferometry in Microgravity) mission the first BEC in space was generated in 2017 [1]. For such challenging experiments realistic simulations are required, explaining experimental results and providing reliable predictions. Therefore, we analytically und numerically study the performance and aberrations of atomic beam splitters in quasi Bragg configuration in three dimensions.

In matter wave interferometers beam splitters are used to prepare coherent superposition of atomic wave packets in momentum space by transferring photon momentum from a laser field. Clearly the aim of such devices is to cover a wide momentum range with unit response. Equivalent to optical systems all matter wave devices require accurate specifications and ubiquitous imperfections need to be quantified. In particular, we characterize the non-ideal behavior due to spatial variations of the laser beam profiles and wave front curvatures, regarding realistic Gaussian laser beams instead of ideal plane waves. In addition, different temporal envelopes of the laser beam will be considered.

We present results of numerical and analytical studies of the velocity dependence of the complex reflectivity of the beam splitter. Finally, our theoretical results are confirmed by experimental data [2].

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[1] M. D. Lachmann, et al., *Creating the first Bose-Einstein condensate in space*, Proc. SPIE 10549, Complex Light and Optical Forces XII, 1054909 (2018)
[2] M. Gebbe, ZARM, Universität Bremen, private communication