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DESIGNING OPTICS FOR QUANTUM MATTER-WAVES

Abstract

Atoms are the ultimate quantum sensors for electro-magnetic fields and gravitational forces. By a feat of nature, atoms occur with bosonic or fermionic attributes, but where produced otherwise identically without any “manufacturing tolerance”.

The QUANTUS collaboration [1], has developed a highly sophisticated, but yet compact and rugged matter-wave device that can be used, for example, as a portable inertial acceleration sensor. The ultimate stress test of this device was completed successfully on Jan. 21. 2017, when the MAIUS [2] sounding rocket mission carried the atomic chip experiment to 243 km above ground and back, performing matter wave interferometry at Mach 4.2. After returning from space, it was recovered and is fully operational.

A central component of the apparatus is the atomic chip that traps paramagnetic atoms in an ultra-high vacuum. A detailed three-dimensional analysis of anharmonic chip trap aberrations, at finite temperatures, with nonlinear self-interactions, matter-wave diffraction effects is required to characterize the setup and to provide pathways for optimization. Another crucial component for matter wave interferometry are the 3D Bragg beam splitters, which have a characteristic velocity sensitivity as well as spatial envelopes.

In this contribution, we will present a technical analysis of the matter-wave sources and optical elements that are used.

References and Acknowledgements:

[1] H. Mütinga et al, Phys. Rev. Lett. 110, 093602 (2013); T. van Zoest et al., Science, 328, 1540 (2010).

[2] MAIUS: http://www.dlr.de/dlr/

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