99 years of matter-wave interference: from foundations to applications

Dennis Schlippert[1, *]

[1] *Leibniz Universität Hannover, Institut für Quantenoptik, Welfengarten 1, 30167 Hannover, Germany*

Almost one century past the first observation of electrons undergoing Bragg diffraction on an Ni target brought upon countless technological breakthroughs, rendering laser-cooled and even ultracold atoms a resource readily available today. This lecture presents atom interferometry as a platform for quantum inertial sensing, with emphasis on precision measurements of acceleration and gravity. We will discuss foundations relevant when performing inertial sensing and present various seminal experiments marking milestones in both tests of fundamental physics as well as applications in navigation and Earth observation.

Finally, we will present the Very Long Baseline Atom Interferometry (VLBAI) facility which enables ground-based atomic matter-wave interferometry on large scales in space and time. With shot noise-limited instabilities better than $10^{-9}\,\mathrm{m/s^2}$ at $1\,\mathrm{s}$ at the horizon, the Hannover VLBAI facility may compete with state-of-the-art superconducting gravimeters, while providing absolute instead of relative gravity measurements thanks to a high-performance seismic attenuation system. Operated with rubidium and ytterbium simultaneously, tests of the universality of free fall at a level of parts in 10^{13} and beyond are in reach. Finally, the large spatial extent of the interferometer allows one to probe the limits of coherence at macroscopic scales as well as the interplay of quantum mechanics and gravity.

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* schlippert@iqo.uni-hannover.de; quantumsensing.de