

Exploring quantum gases for interferometry (C)

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Ultra-cold quantum gases promise to boost the sensitivity of inertial matter-wave interferometers and open the avenue to achieve higher accuracies. In fundamental physics, these sensors are pursued e.g. for testing quantum mechanics, general relativity, detection of gravitational waves or scrutinizing concepts for dark matter and energy. Exploiting quantum gases for high-precision interferometry places high demands on their control and manipulation. We take benefit of various platforms such as the very-long-baseline atom interferometer, the Bremen drop tower, the Einstein elevator in Hannover, sounding rockets and the international space station to advance the necessary methods and achieve the targeted resolution. The DLR-mission MAIUS-1 demonstrated Bose-Einstein condensation and performed first interferometry experiments during the space travel of a sounding rocket. NASA's Cold Atom Laboratory continues this research in orbit on the ISS. Starting from a rubidium Bose-Einstein condensate, recently lowest expansion energies have been achieved by us in the Bremen drop tower as required for extending atom interferometry over several seconds. Exploring these methods to quantum mixtures not only opens up new physics in the absence of buoyancy, but also adds challenges for exploiting these mixtures for interferometry. Interferometers based on two different chemical elements have been proposed for quantum tests of the equivalence principle on the ISS as well as on satellites. Currently we prepare a sounding rocket mission to investigate the simultaneous generation and manipulation of potassium and rubidium condensates. Together with CAL, these experiments will prepare the DLR-NASA multi-user facility BECCAL for research on quantum gas mixtures and interferometry as well as enhance the readiness level of methods required for STE-QUEST, a proposal for a satellite mission currently studied within ESA's VOYAGE 2050 program.

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