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Space-borne matter-wave interferences

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Bose-Einstein condensation (BEC)was awarded with the Nobel prize only 18 years ago. At that time one only could "speculate on areas for the application of BEC. The new "control" of matter which this technology involves is going to bring revolutionary applications in such fields as precision measurement and nanotechnology." Today BEC interferometry is a cornerstone for applications of cold atoms on ground and in space and represents a new field in matter wave optics. These interferometers strive to increase the sensitivity by coherently spitting and separating wave packets over macroscopic spatial and temporal scales. Bose-Einstein condensates (BECs), representing a textbook example for a macroscopic wave packet, are the ideal source for performing this kind of interferometry in very long baseline interferometers stretching out over seconds on ground and during even longer interferometry times in space. , BEC interferometry was exploited for the first time in the extended free fall with a chip-based atom laser for Rubidium 87Rb in the QUANTUS collaboration. The design was successfully employed for a rocket based test of such an BEC interferometer. In the talk, I will present the first interferometry experiments performed on the sounding rocket mission MAIUS-1 in space. The experiment pave the way for future space experiments by NASA's CAL II and the envisioned DLR-NASA project of "BECCAL", a multi-user facility for experiments on quantum matter, quantum optics and BEC interferometry. Among others, they will demonstrate important techniques necessary for satellite based quantum tests of Einsteins principle of equivalence as pursued by the STE-QUEST mission, for satellite gravimetry and future gravitational wave detection based on ultracold atoms.QUANTUS cooperation comprises the group of C. Lämmerzahl (Univ. Bremen), A. Peters (Humboldt Univ. Berlin/Ferdinand Braun Institut), T. Hänsch/J.Reichel (MPQ/ENS), K. Sengstock/P. Windpassinger (Univ. Hamburg/Univ. Mainz), R. Walser (TU Darmstadt), and W.P. Schleich (Univ. Ulm). project is supported by the German Space Agency Deutsches Zentrum für Luft- und Raumfahrt (DLR) with funds provided by the Federal Ministry of Economics and Technology (BMWI) under grant number DLR 50 WM 0346. We thank the German Research Foundation for funding the Cluster of Excellence QUEST Centre for Quantum Engineering and Space-Time Research.