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THE DROP TOWER BREMEN AS A SOURCE FOR ATOM OPTICAL EXPERIMENTS IN GRAVITATION-FREE CONDITIONS

Abstract

Since the possibility of trapping and cooling neutral atoms, ultracold quantum degenerate gases have shifted boundaries in a growing field of modern physics appreciated by the Nobel Prizes in 1997 and 2001. The current developments in the domain of atom optics lead to an utilization of ultracold quantum matter techniques in unique practical applications as high-precision atomic clocks, atom interferometer technologies and inertial sensing instruments for gravity field mapping, underground structure detection, autonomous navigation, as well as precision measurements in fundamental physics. The expectations of even higher precision measurements can be performed by arbitrarily extending the time of unperturbed evolution of quantum degenerate systems. In respect thereof weightlessness provides an outstanding basis for such measurements and applications. Motivated by these prospects, many national and international groups have initialised research programs aiming for compact, transportable and ruggedly designed atom optical experiments, which might be launched in parabolic flights and space applications.

Thanks to an easy access to low gravity on earth, realization of quantum degenerate gases in excellent microgravity conditions at the Drop Tower Bremen opened a new kind of perspectives on earth-bound experiments, e.g., to currently achieve longest expansion times of Bose-Einstein condensates (up to one second). Thus, ultracold quantum matter in an environment of weightlessness represents an emerging area of science in quantum engineering with an impressive potential for a future technology and multidisciplinary applications.

We will report on the first experimental demonstration and investigation of rubidium Bose-Einstein condensates in the environment of weightlessness at the Drop Tower Bremen, a facility of ZARM, performed within the QUANTUS collaboration. Our approach is based on a compact, mobile, robust and autonomous operating drop capsule setup, which has to withstand decelerations of around 50g on every free fall. So far, we have successfully accomplished more than 200 drops with the QUANTUS apparatus since the beginning. On the basis of the QUANTUS project we are currently engineering a drop capsule setup to realize a new kind of atom interferometer experiment suitable for drop tower operations. We will give a status report of this new project initialized by the PRIMUS collaboration as well.

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