Advanced laser systems for coherent manipulation of matter waves in microgravity

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Abstract

Targeting a long-term goal of studying cold quantum gases on a space platform, we perform preliminary experiments under microgravity conditions at the ZARM drop tower in Bremen. A sounding rocket mission is planned for the near future. In this context compact and robust laser systems have been developed.

This poster will present the laser system capable of performing dual-species atom interferometry experiments with degenerate Bose-Fermi mixtures of ^{87}Rb and ^{40}K at the drop tower. In particular, we show the concepts of a hybrid integrated master-oscillator power amplifier (MOPA) and a highly miniaturized, spectroscopy stabilized reference laser. The MOPA consists of a DFB laser chip, a tapered amplifier (TA), and micro-optical components, all integrated on a $10 \times 50\ mm^2$ micro-bench. The reference laser combines this micro-bench technology with a mesoscopic vapor cell.

Two different concepts of Raman lasers for coherent manipulation of the wave packets will be shown in detail. The one is basing on a fiber electro-optical modulator (EOM) followed by injection lock of a DFB laser diode. The other one utilizes a double-passed acousto-optical modulator (AOM).

Special challenges in the construction of this system are posed by the drop-tower environment which entails critical vibrations during drop capsule release and peak decelerations of up to 50 g during the launch of the catapult and during recapture at the bottom of the tower. All optical and electronic components have thus been designed with stringent demands on mechanical stability and reliability. These features of the laser system open new routes to quantum optics experiments also on other microgravity platforms, like ballistic rockets or the International Space Station (ISS).

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