Mirror, beam splitter, and resonator for atom lasers using Raman transitions

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We report the realization of atom optical elements for coherent matter waves using optical hyperfine Raman transitions. An atom laser beam which is output coupled from a Bose-Einstein condensate in the magnetically untrapped state $|F=1, m_F=0\rangle$ is transferred into the magnetically trapped state $|F=2, m_F=1\rangle$ using a two photon transition. In this state the atoms are reflected by the potential of the magnetic trap. On their way up the atoms pass the Raman lasers again and can be transferred back into the $|F=1, m_F=0\rangle$ state. This technique allows for precise spatial and temporal control of the interaction of the atoms with the magnetic trapping potential. Since the atoms are reflected by the magnetic trapping potential only a few milliwatts of laser power are sufficient

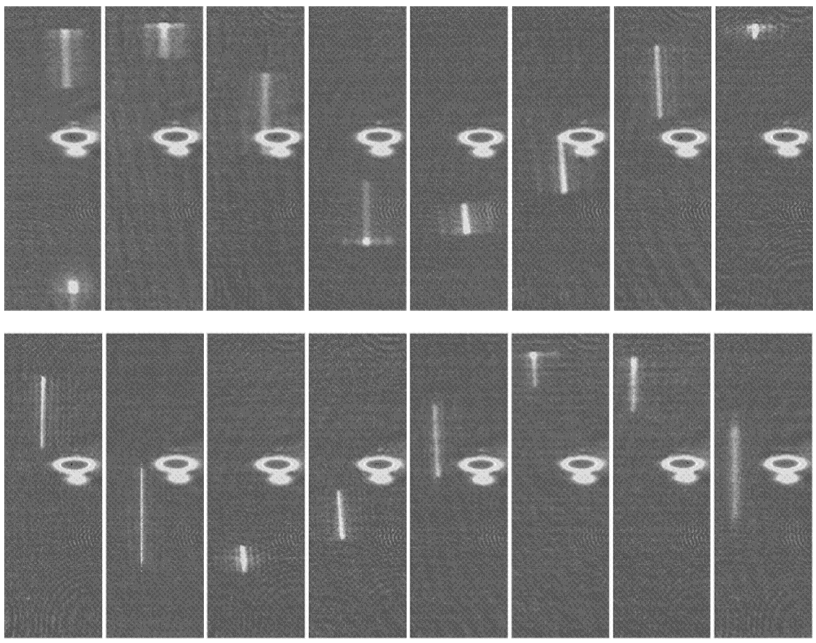

Figure 1: Atom laser beam stored in a resonator formed by the magnetic trapping potential. Time interval between the absorption images: 2 ms, height of the images: 2.2 mm.

The reflectivity of the mirror can be changed by tuning the power of the Raman lasers and therefore the coupling strength between the hyperfine levels. Thus this scheme can also be used as a beam splitter.

Avoiding the second transition through the Raman interaction zone leaves the atoms in the magnetically trapped state where the magnetic trapping potential acts as resonator (Fig. 1). Due to the axial curvature of the magnetic trapping potential focusing and defocusing of the atom laser beam is observed.