Abstract

This thesis reports on the realization of two novel optical trapping schemes that allow for the confinement of dense atomic ensembles close to a material surface. The microtraps use the strong optical dipole force arising from large intensity gradients of evanescent wave light fields and of a strongly focussed beam. The resulting trapping conditions are favorable to implement efficient evaporative cooling or to create a system of reduced dimensionality.

The first microtrap, the focussed beam surface trap, tightly confines an atomic cesium ensemble using a repulsive evanescent wave light field, a strongly focussed far-detuned beam and gravity. The focussed beam is oriented vertically with respect to the dielectric surface and its attractive dipole force provides the horizontal confinement of the trap. The combination of repulsive evanescent wave and gravity confines the atomic ensemble vertically. This conservative microtrap potential is loaded with atoms from a large and dense reservoir of atoms near the dielectric surface via elastic collisions. The combination of the large reservoir and the small dimple potential leads to a local increase in density and phase-space density by up to a factor of 300 and gives rise to elastic scattering rates of about 2 kHz. Subsequent efficient evaporative cooling is applied to further increase the phase-space density of the unpolarized ensemble of initially several million cesium atoms. At $T = 400\,\mathrm{nK}$ a phase-space density of 1.6×10^{-2} is observed showing this approach's potential to reach the Bose-Einstein condensation point.

In a second microtrap scheme, the double evanescent wave surface trap, two overlapping evanescent waves, one repulsive and short-ranged and the other attractive and long-ranged, are used to create a three-dimensional microtrap potential close ($\approx 1\,\mu\mathrm{m}$) to the dielectric surface. Up to 1.5×10^5 atoms can be transferred from the focussed beam surface trap and are then evaporatively cooled to around 100 nK by ramping down the attractive dipole potential. Under these conditions the vertical motion of the atoms in the strongly confining, highly anisotropic potential is inherently quantum mechanical. The vertical ground-state population at this point is 63 % and the phase-space density has increased to about 0.1. Consequently the crossover to two-dimensionality has been reached.