Abstract

In this thesis, we describe the realization of a novel optical dipole trap for erbium atoms. The trap is based on time-averaged potentials and is thus tunable in geometry. We investigate both theoretically and experimentally the dynamic polarizability of ground-state erbium atoms. The polarizability is a very important quantity for the understanding of the atomic properties of erbium and, prior to this thesis, its value was unknown. We measure a dynamic polarizability of $\mathrm{Re}(\alpha) = (84 \pm 2 \pm 18)$ a.u. for erbium atoms in a 1064-nm laser field, which is 47 % lower than the one we calculated based on the best knowledge of the erbium atomic spectrum. This discrepancy might points to a too rough knowledge of the atomic level structure or to novel unexpected effects arising in sub-merged shell atoms. Further investigations both in theory and experiments are highly needed.

For our novel optical dipole trap setup we use a scanning system consisting of an acousto-optical modulator, electronics and a customized optical setup. The dipole trap beam is shifted perpendicular to its horizontal axis, creating time-averaged potentials when the scan over a range of positions is fast enough compared to the trap frequency. The aspect ratio of the dipole trap can be tuned from 1.5 to 15. With the new dipole trap system we can load up to 35 % of MOT atoms to the dipole trap, which is related to mode-matching arguments. Further the density at each evaporation step can be optimized, leading to a large overall evaporation efficiency of 3.5. This improvements result in up to three times larger numbers in the pure BEC compared to our previous experiments.

With the new tunable dipole trap we are confident that in future we can investigate geometry-dependent anisotropic quantum effects, unique to dipolar gases.