Abstract

This thesis reports on the realization of the first Bose-Einstein condensate (BEC) of ^{133}Cs. Condensation is achieved in the lowest internal state ($F = 3, m_F = 3$) by evaporative cooling in an optical trap.

Cesium has unique scattering properties, which have prevented Bose-Einstein condensation for many years. Much knowledge has been collected on these properties in many experiments world-wide. The experimental setup constructed during this thesis was designed with that knowledge in mind to avoid the peculiar pitfalls cesium has to offer and to use its special properties on the path towards BEC.

A shallow quasi-electrostatic optical dipole trap formed by two 100-W CO_2 lasers in combination with a magnetic levitation field allows for selective trapping of the absolute internal ground state, ensuring perfect spin polarization. In first experiments, the complete suppression of inelastic two-body losses in this setup was used to perform detailed measurements of three-body recombination effects at large scattering length a [Web03b]. The magnetic tunability of a via Feshbach resonances was employed to experimentally confirm for the first time the theoretically predicted a^4 scaling of the three-body recombination rate coefficient and to determine the value of a universal scaling factor $n_l C$ included in the theory. The value of $n_l C = 225$ agrees with the predictions within its error limits.

A further result of the three-body recombination measurements, strong evidence for recombination heating, has been of crucial importance for identifying a suitable path towards condensation. An extension of the setup, an optical microtrap ("dimple"), avoids the detrimental effects of recombination heating and allows for efficient evaporative cooling by lowering the optical potential. Using the tunable scattering length to optimize the evaporation path, Bose-Einstein condensation was achieved at a critical temperature of 50 nK, with a maximum of 16000 atoms in the condensate phase [Web03a].

First experiments with the BEC demonstrate the strong dependence of the condensate mean-field energy on the magnetic field. By briefly switching to different scattering lengths just before releasing the sample from the trap, imploding, exploding, and non-interacting "frozen" condensates are realized. The lowest kinetic energy measured in the expansion of a condensate is $\frac{1}{2}k_B \cdot (220 \pm 100)$ pK.