Abstract

Our field of research is the crossover from a Bose-Einstein condensate (BEC) to a Bardeen-Cooper-Schrieffer (BCS) superfluid. A gas of fermionic ^{6}Li atoms is cooled to ultra-low temperatures in an ultra-high vacuum environment. It is confined in an optical dipole trap formed by a single focused laser beam. The two-body interaction is controlled by means of a Feshbach resonance. Absorption imaging reveals the density distribution of the atom cloud. This experimental setup allows to investigate different interaction regimes of an ensemble of fermionic atoms.

This thesis reports on two technical upgrades of the control and detection of the atomic sample:

- An optical dipole trap that can be moved and deformed in a versatile and well-controlled way: The design and implementation of a scanning system, which deflects the single focused laser beam, is discussed. A slow deflection represents a displacement of the trap because the atoms follow adiabatically. For rapidly modulated deflection, the atoms just respond to the average laser beam intensity; the trap is effectively deformed.

- A high-resolution imaging system that is optimized for imaging through a window of a vacuum chamber: The window induces aberrations to the diverging imaging light especially if the window is not perpendicular to the imaging axis. We report on the correction of those aberrations to gain high resolving power.

These upgrades were developed for the ^{6}Li apparatus but can be easily adapted to other cold-atom experiments.

The new scanning and imaging systems are currently employed to excite and measure collective oscillations of the atom cloud and open up the way to many more exciting novel experiments.