Abstract

This thesis reports on the construction and characterization of a novel surface trapping apparatus for experiments with ultracold cesium atoms. As a first application in the realm of three-body physics, measurements of recombination rates were performed to investigate an Efimov resonance.

Optical dipole traps based on evanescent waves are used to trap and cool atomic samples in close proximity to a dielectric surface. Starting from an existing experimental setup, a complete redesign of the vacuum system was performed in order to replace an old stainless steel chamber by a glass cell with integrated prism. The main technical improvements of the new apparatus are superior optical access, better surface quality of the prism and faster magnetic field control. In addition, the carefully constructed magnetic coils are now capable of producing magnetic gradients to partially compensate the gravitational force.

In the surface trap, a sequence of cooling methods is applied to prepare thermal gases at temperatures down to 50 nK. These methods include Raman sideband-cooling on the surface and a novel evanescent-wave trap that employs an 80 W high-power diode laser. A standing-wave surface trap is demonstrated that provides highly anisotropic confinement while preserving long lifetimes and presents a promising tool for future experiments on two-dimensional systems.

The technical improvements were essential for measurements of three-body recombination which have led to the main scientific result of this thesis. By exploiting the unique magnetic tunability of interactions in ultracold cesium gases, a dramatic three-body loss resonance at large negative scattering lengths was revealed. In collaboration with another experiment [Kra06b], the resonance could be identified as a manifestation of an Efimov state which confirmed a long-standing theoretical prediction. In further measurements, the position of the resonance was accurately determined in dependence of the temperature of the atomic sample. As a result, the scattering length of maximum loss shifted by about 50 Bohr radii when the temperature was reduced from 500 nK to 50 nK. This observation serves as a testing ground for several theoretical models describing the evolution of a bound Efimov state into a continuum resonance. The direction, magnitude and saturation behavior of the shift are well reproduced by the models and hence further confirm the applicability of Efimov's framework to the cesium system.