

## Abstract

The experimental realization of Bose-Einstein condensation with atomic gases opened up a new fascinating research area. Since 1995 a myriad of fundamental effects of weak interacting Bose-Einstein condensates have been studied, many of them based on the non-linearity of the system. In almost all experiments the behavior of only one-component condensates is analyzed. Only in two groups at JILA and at MIT (as well as at Georgia Tech simultaneously to this thesis) the special effects of two- and three-component condensates have been studied.

In the present thesis the complex dynamics of five-component Bose-Einstein condensates is investigated experimentally and theoretically. Based on a  $F=2$  spin-system an important contribution to the magnetic interaction in atomic quantum-gases is made. The main emphasis of this work is on the dynamics of the spin-states, the magnetic groundstate and its dependence on various parameters and the different loss-channels.

The experiments are realized with  $^{87}\text{Rb}$  atoms within the hyperfine manifold  $F=2$ . The required apparatus as well as all essential laser-systems of the experiment have been designed and built.

One main result of the measurements is the observation of a polar behavior of  $^{87}\text{Rb}$  condensates in the  $F=2$  hyperfine state. It is shown in this thesis that this does not unambiguously imply a polar phase for the atoms. The groundstate of the cyclic phase can be shifted by a magnetic field into a region where polar behavior also represents the spin-state with minimum energy. The cyclic phase does not exist in spin-one systems and is a result of the complex interactions in spin-two systems. In this thesis the effects of magnetic fields for spin-two systems with respect to the ground states are analyzed in detail.

In comparison to the experiments with  $^{23}\text{Na}$  the experimental investigations of spindynamics show a very fast built up of the population in the “new” spin components ( $\sim 10$  ms versus  $\sim 1$  s). This effect allows for experiments with spindynamics faster than the thermalization of the ensemble for the first time. Accompanying to the detailed experimental results a model for the analysis of spindynamics has been developed. In particular this model contains the influence of additional magnetic offset fields to the spindynamics.

Furthermore a magnetization of condensates with initial total spin unequal to zero has been observed. This effect results from spindynamics combined with spin-dependent losses. These losses appear due to transitions into the lower hyperfine state. The two-body loss rates for a mixture of the spin-states  $|m_F = +2\rangle$  together with  $|m_F = -2\rangle$  as well as for an equipartition over all  $m_F$  components have been determined.

The results of this thesis give an important extension to the understanding of multi-component Bose-Einstein condensates.