

Ultracold sodium and rubidium mixtures: collisions, interactions and heteronuclear molecule formation

Grant # DE-FG02-03ER15450

Principal Investigator:

Dr. Chandra Raman
Associate Professor
School of Physics
Georgia Institute of Technology Atlanta, GA 30332-0430
craman@gatech.edu

Program:

This program centers on quantum gases of ^{23}Na and ^{87}Rb , with the goal of observing collisions and interactions in binary mixtures. In the current period our research has focused on single species interactions and dynamics with a ^{23}Na Bose-Einstein condensate.

Work completed to date:

We have recently begun to explore the correspondence between a spinor Bose-Einstein condensate of sodium atoms and a quantum-mechanical rotor. Spinor BECs can offer unique insights into field-induced alignment in diatomic molecules. The role of the external aligning field is played by an external magnetic field through the quadratic Zeeman effect. Molecular rotation corresponds to rotations in spin space induced purely by interactions between atoms. For sodium atoms, with total hyperfine spin $F = 1$, the spin-dependent interactions are anti-ferromagnetic, leading to a nematic order parameter where spin alignment rather than orientation is the relevant degree of freedom. Thus a sodium BEC corresponds particularly closely to a homonuclear diatomic molecule. The moment of inertia is macroscopic in size, and therefore is very easily aligned by weak magnetic fields in the range of 0.1-1 Gauss. However, unlike a heavy diatomic, thermally occupied rotations are negligible, and the spinor BEC is very close to its energy ground state. Thus it offers insights into field induced alignment and wavepacket dynamics in a regime typically not easily accessed in other systems.

We observed the dynamics of the spinor BEC consisting of a pure $m=0$ spin projection as it was rapidly tuned from positive to negative quadratic energy shift q . The value $q = 0$ constitutes a quantum critical point. Negative q was realized using the AC Stark shift from a far-off resonance microwave field. By spatially imaging the 3 spin components of a sodium BEC, we observed a rapid dispersion of the initially localized wavepacket associated with the formation of pairs of atoms with spin projection ± 1 . These pairs appeared through a dynamical instability associated with the quantum phase transition as localized spin domains that grew in size, exhibiting coarsening dynamics.

Anticipated Unexpended Funds by 10/31/2011: None

Personnel Supported:

1. PI summer salary
2. Graduate Student Anshuman Vinit
3. Postdoc Carlo Samson
4. Undergraduate student Joshua Raimist