Results from NSF Award No. 0555554 (2006-2010)

This research program focused on experimental studies of topological excitations of sodium Bose-Einstein condensates (BECs) and the study of ultracold mixtures of sodium and rubidium atoms.

- In collaboration with my colleague, Li You, we devised a protocol for pumping vorticity into a Bose-Einstein condensate using time-varying magnetic fields, and therefore for the realization of quantum correlated states of large angular momentum. We devised optimal procedures for continuously increasing or decreasing a condensate's vorticity (up to 30 hbar of circulation) by repeating two-step magnetic field manipulation protocols.

- Light-Induced Atomic Desorption for loading a Sodium Magneto-Optical Trap. In this work we studied photon-stimulated desorption, also known as light-induced atomic desorption, of sodium atoms from a vacuum-cell glass surface used for loading a magneto-optical trap (MOT). We observed a steep wavelength dependence of the desorption process above 2.6 eV photon energy, a result significant for estimations of sodium vapor density in the lunar atmosphere. Up to 3.7×10^7 Na atoms were confined under ultra-high vacuum conditions, creating promising loading conditions for a vapor cell-based atomic Bose-Einstein condensate of sodium.

- Ultracold magnetically trapped sodium and rubidium. We leveraged our expertise in BEC experiments with atomic sodium to initiate a program to study dual BEC of two species based upon sympathetic cooling of Rb. We loaded Na and Rb into a magnetic trap and found no evidence for large interspecies inelastic collisional losses in the temperature range 100 − 1000μK. This promising result suggests that further evaporation of Na should result in sympathetic cooling (see Figure 1).

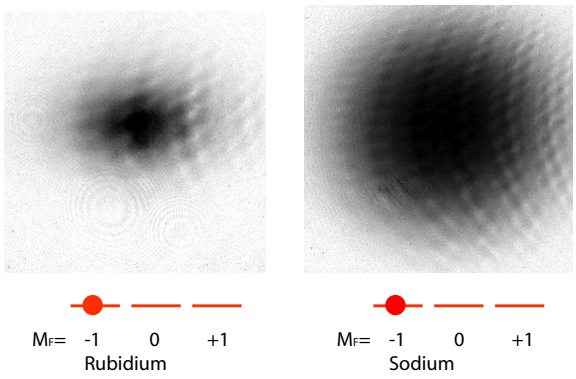

Figure 1: First observation of magnetically trapped mixtures of ^{23}Na and ^{87}Rb. Shown are absorption images of 10^8 Rb atoms (left) and 10^9 Na atoms (right) at temperatures of roughly 600 μK in a trap with an axial field gradient of 350 Gauss/cm. The trapped sub level of the $F = 1$ hyperine level is indicated below each image. In initial experiments ultracold mixtures were observed for more than 15 seconds, providing evidence that resonant inelastic collisions were not present.

- BEC in toroidal potentials. In this work we devised a new method of generating flexible, configurable optical traps for atoms using a two-axis acousto-optic deflector. By rapidly scanning a focused, far off-resonance infrared laser beam at 10 kHz rotation rate, atoms were trapped in a potential that could be arbitrarily configured using computer control. Our preliminary results demonstrated lifetimes of up to 10 seconds in this trap, which was a hybrid of an optical ring with a 31 Hz transverse oscillation frequency TOP (Time- Orbiting Potential) trap. In order to exert fine control over the potential minimum, we adjusted the laser beam intensity at every scan point. Using this technique we realized a BEC in a toroidal potential (see Fig. 2).

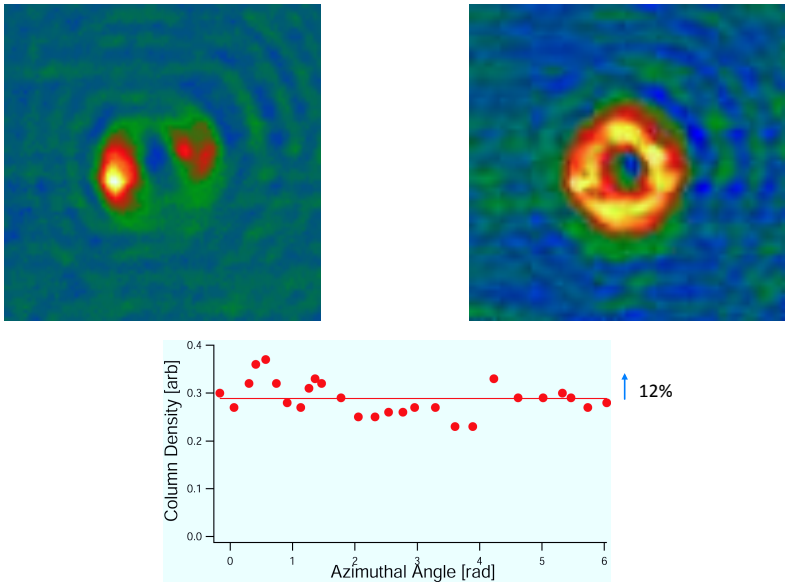

Figure 2: Toroidal BEC. A ring-shaped BEC was realized in a rapidly rotating optical dipole trap. Phase contrast images show the *in-situ* condensate density distribution with a 215 μm field of view in each image. (Left) No intensity correction and (Right) Intensity correction applied by adjusting the intensity on a point-by-point basis during the scan. After smoothing of the intensity profile the condensate occupied the entire ring, with an azimuthal density variation of only 12 %. Data taken from an oral presentation by Sergio Muniz at the 2006 DAMOP meeting in Knoxville, Tennessee.

Publication List:

1. Z. F. Xu, P. Zhang, C. Raman and L. You, ***Continuous vortex pumping into a spinor condensate with magnetic fields.*** Phys. Rev. A **78**, 043606 (2008).
2. Gustavo Telles, Tetsuya Ishikawa, Matthew Gibbs and Chandra Raman, ***Light-Induced Atomic Desorption for loading a Sodium Magneto-Optical Trap***, Phys. Rev. A 81, 032710 (2010).
3. Sergio R. Muniz, Devang S. Naik, Mishkatul Bhattacharya and Chandra Raman, ***BEC in toroidal potentials,*** 2006 Bulletin of the American Physical Society.