

**Quantum Degeneracy and Interactions in the  
 $^{87}\text{Rb}$  -  $^{40}\text{K}$  Bose-Fermi Mixture**

by

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The final copy of this thesis has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.

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Quantum Degeneracy and Interactions in the  $^{87}\text{Rb}$  - $^{40}\text{K}$  Bose-Fermi Mixture

Thesis directed by Associate Professor Deborah S. Jin

An apparatus for producing dilute-gas quantum degenerate Bose-Fermi mixtures is presented. The experiment uses forced evaporative cooling to obtain a nearly pure  $^{87}\text{Rb}$  Bose-Einstein condensate immersed in a gas of sympathetically cooled  $^{40}\text{K}$  atoms at 0.2 times the Fermi temperature. The design, construction, and operation of the apparatus are described in detail. The onset of quantum degeneracy is characterized and contrasted between species, revealing the effects of quantum statistics on the bulk properties of the gases.

The apparatus is then used to study the interactions between species in ultracold non-degenerate mixtures. Measurements of rethermalization rates are used to determine the elastic scattering cross-section between species. From these measurements the magnitude of the inter-species *s*-wave scattering length is determined. The scattering length is central to characterizing a variety of static and dynamic properties of the mixture. The apparatus is additionally used to study for the first time Feshbach resonances in the collisions between  $^{87}\text{Rb}$  and  $^{40}\text{K}$  atoms. These resonances present a means for experimentally tuning the scattering length between species to any desired value. Prospects for future experiments exploiting this real-time control over the interactions are discussed.

## Dedication

For my parents.

## Acknowledgements

I would like to acknowledge the contributions of a number of people to the work described in this thesis. It is the nature of the JILA quantum gas collaboration that literally dozens of people will at one time or another contribute ideas to each experiment.

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in order to quickly estimate which things I should worry about and which could be safely neglected.

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