

**Ultracold Atoms, Circular Waveguides, and Cavity QED with  
Millimeter-scale Electromagnetic Traps**

by

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Spring 2007

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University of California, Berkeley

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## Abstract

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Electromagnetic Traps

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Doctor of Philosophy in Physics

University of California, Berkeley

Professor Dan M. Stamper-Kurn, Chair

The construction of a laser cooling/trapping apparatus with a versatile mm-scale magnetic trap for ultracold atoms is described herein. The design, operation, and performance of this unique trap are presented. The manipulation of this magnetic trapping system facilitated the Bose-condensation of  $^{87}\text{Rb}$  atoms in a variety of magnetic traps, most notably a millimeter radius circular magnetic trap for ultracold atoms. The dynamics of the quantum degenerate atom beam in this geometry are explored, as well as future applications with refinements of this system. A new probe of the phase space distribution of a generalized atomic beam is presented, and this probe was employed in the circular magnetic waveguide to characterize the quantum state of the system. Finally, this mm-scale magnetic trap was integrated with a mm-scale high-finesse optical cavity which accesses the strong coupling regime of cavity quantum electrodynamics (QED). Large ensembles of ultracold atoms were delivered to this cavity, and the first experimental results of this new dispersive regime of many-atom cavity QED are described.

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Professor Dan M. Stamper-Kurn  
Dissertation Committee Chair



To my father,  
Maurice Joseph Moore  
(1932 - 2007)

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*‘Ndanka, ndanka’ mo jappa golo. - Wolof proverb*

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On into high school, where my lazy academic philosophy hit a very significant roadblock in Kevin Connell's English class. It was here that I first discovered what really makes the written word worth reading, and haven't viewed it the same since. All of a sudden Stephen King seemed like a hack and I found myself turning to the likes of Orwell, Hemingway, Vonnegut, and Heller to satisfy my newfound requirement that books boast not just a plot but artistry, depth, and humanity. That said, I still think The Scarlet Letter is horrible.

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Underneath the undeniably happy occasion of completing my Ph.D. is a deep sadness that my father, Maurice Joseph Moore, did not live to see me become the second Dr. Moore. I know how much he would have loved seeing this day come, and it is to him that I dedicate this work.

---

<sup>1</sup>There was plenty.