Abstract for an Invited Paper
for the DAMOP09 Meeting of
The American Physical Society

Vortex configurations of ultracold bosons in rotating optical lattices[1]

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Atomic clouds in rotating optical lattices are at the intellectual intersection of several major paradigms of condensed matter physics. An optical lattice simulates the periodic potential ubiquitous in solid state physics, while rotation probes the superfluid character of these cold atomic gases by driving the formation of quantized vortices. Here we concentrate on our own work investigating the vortex configurations that emerge in a trapped Bose-Einstein condensate in a rotating optical lattice. We investigate this system in two separate regimes. First, we find that close proximity to the Mott state dramatically affects the vortex configurations. To illustrate we give examples in which the vortices: (i) all sit at a fixed distance from the center of the trap, forming a ring, or (ii) coalesce at the center of the trap, forming a giant vortex. Second, we investigate the regime far from the Mott phases, where the competition between vortex-vortex interactions and pinning to the optical lattice results in a complicated energy landscape, leading to hysteresis. The qualitative structure of the vortex configurations depends on the ratio between the vortex density and the site density – with regular lattices forming when these quantities are commensurate. In both regimes we simulate absorption images after time-of-flight expansion, and thus show how these states could be observed in the laboratory.

[1]This material is based on work supported by the National Science Foundation through grant No. PHY-0758104

[2]Work done in collaboration with Erich Mueller at Cornell University.