DAMOP09-2009-020019
Abstract for an Invited Paper
for the DAMOP09 Meeting of
the American Physical Society

Cold atoms in a rotating optical lattice[1]

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We have demonstrated a novel experimental arrangement which can rotate a two-dimensional optical lattice at frequencies up to several kilohertz. Our arrangement also allows the periodicity of the optical lattice to be varied dynamically, producing a 2D "accordion lattice" [1]. The angles of the laser beams are controlled by acousto-optic deflectors and this allows smooth changes with little heating of the trapped cold (rubidium) atoms. We have loaded a BEC into lattices with periodicities ranging from 1.8μm to 18μm, observing the collapse and revival of the diffraction orders of the condensate over a large range of lattice parameters as recently reported by a group in NIST [2]. We have also imaged atoms in situ in a 2D lattice over a range of lattice periodicities. Ultracold atoms in a rotating lattice can be used for the direct quantum simulation of strongly correlated systems under large effective magnetic fields, i.e. the Hamiltonian of the atoms in the rotating frame resembles that of a charged particle in a strong magnetic field. In the future, we plan to use this to investigate a range of phenomena such as the analogue of the fractional quantum Hall effect.

[1] R. A. Williams, J. D. Pillet, S. Al-Assam, B. Fletcher, M. Shotter, and C. J. Foot, "Dynamic optical lattices: two-dimensional rotating and accordion lattices for ultracold atoms," Opt. Express 16, 16977-16983 (2008)
[2] J. H. Huckans, I. B. Spielman, B. Laburthe Tolra, W. D. Phillips, and J. V. Porto, Quantum and Classical Dynamics of a BEC in a Large-Period Optical Lattice, arXiv:0901.1386v1

[1]Funding from EPSRC and ESF.