# Abstract for GR-TR Conference on Statistical Mechanics and Dynamical Systems

Talk Invited | Invited Talk

## Ultra-cold atoms in rotating optical lattices

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Experiments on ultracold atoms in optical lattices opened up a new avenue to study correlated quantum states. The versatility of cold atom experiments hold promise for the experimental realization of many models that were first introduced for solid-state systems.

One such model is the study of particles moving in a tight binding lattice under a magnetic field. When the magnetic flux per plaquette of the lattice becomes of the order of a flux quantum $hc/e$, the single particle energy spectrum forms a complicated self-similar structure, known as the Hofstadter butterfly. It has not been possible to reach this regime in ordinary condensed matter experiments due to the required high magnetic fields. However, the ultracold atom experiments are extremely flexible and it should be possible to create required effective magnetic fields in optical lattice experiments. A conceptually simple way of creating an effective magnetic field is to rotate the optical lattice, as demonstrated in a recent experiments.

We study a number problems within the context of this model: 1) Superfluid-Insulator (Mott) transition of Bosons in a rotating optical lattice. 2) Realization and detection of Topological Hofstadter Insulator with fermions in an optical lattice. 3) Effective Hamiltonians for the excited (p-band) atoms in a rotating optical lattice.

We find that the effective magnetic field created by rotation has non-trivial effects on many body properties. For bosons, the Mott transition boundary is scaled by the bandwidth of the Hofstadter butterfly, and new Fractional Quantum Hall phases appear. For non-interacting fermions, the quantized Hall conductance is related to the change of density with rotation. Rotation also creates a non-zero critical attraction strength for BCS instability by opening up gaps. For the excited bands we find a systematic way of applying Peierls substitution to obtain effective Hamiltonian for the system.