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Experimental Realization of the Harper-Hofstadter Model

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Extensions of Berry's phase and the quantum Hall effect have led to the discovery of new states of matter with topological properties. Traditionally, this has been achieved using magnetic fields or spin–orbit interactions, which couple only to charged particles. For neutral ultracold atoms, synthetic magnetic fields have been created that are strong enough to realize the Harper–Hofstadter model. In this talk, I report on work studying Bose–Einstein condensation in the Harper–Hofstadter Hamiltonian with one-half flux quantum per lattice unit cell. The diffraction pattern of the superfluid state directly shows the momentum distribution of the wavefunction, which is gauge-dependent, and it reveals both the reduced symmetry of the vector potential and the degeneracy of the ground state. I present an adiabatic, many-body state preparation protocol via the Mott insulating phase and show the superfluid ground state in a three-dimensional lattice with moderate interactions. I will discuss progress towards a triple-superlattice implementation as well as prospects for exploring exotic states close to the Mott transition.