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Realization of the Harper Hamiltonian with Artificial Gauge Fields in Optical Lattices HIROKAZU MIYAKE[1], GEORGIOS SIVILOGLOU, COLIN KENNEDY, WILLIAM CODY BURTON, WOLFGANG KETTERLE, MIT — Systems of charged particles in magnetic fields have led to many discoveries in science–such as the integer and fractional quantum Hall effects–and have become important paradigms of quantum many-body physics. We have proposed and implemented a scheme which realizes the Harper Hamiltonian, a lattice model for charged particles in magnetic fields, whose energy spectrum is the fractal Hofstadter butterfly. We experimentally realize this Hamiltonian for ultracold, charge neutral bosonic particles of ^{87}Rb in a two-dimensional optical lattice by creating an artificial gauge field using laser-assisted tunneling and a potential energy gradient provided by gravity. Laser-assisted tunneling processes are characterized by studying the expansion of the atoms in the lattice. Furthermore, this scheme can be extended to realize spin-orbit coupling and the spin Hall effect for neutral atoms in optical lattices by modifying the motion of atoms in a spin-dependent way by laser recoil and Zeeman shifts created with a magnetic field gradient. Major advantages of our scheme are that it does not rely on near-resonant laser light to couple different spin states and should work even for fermionic particles. Our work is a step towards studying novel topological phenomena with ultracold atoms.

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