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Realizing the Harper Hamiltonian and Spin-Orbit Coupling with Laser-Assisted Tunneling in an Optical Lattice COLIN KENNEDY, HIRO MIYAKE, CODY BURTON, WOO CHANG CHUNG, GEORGIOS SIVILOGLOU, WOLFGANG KETTERLE, Massachusetts Inst of Tech-MIT — The study of charged particles in a magnetic field has led to paradigm shifts in condensed matter physics including the discovery of topologically ordered states like the quantum Hall and fractional quantum Hall states. Quantum simulation of such systems using neutral atoms has drawn much interest recently in the atomic physics community due to the versatility and defect-free nature of such systems. We discuss our recent experimental realization of the Harper Hamiltonian and strong, uniform effective magnetic fields for neutral particles in an optical lattice [1]. Additionally, our scheme represents a promising system to realize spin-orbit coupling and the quantum spin Hall states without flipping atomic spin states and thus without the intrinsic heating that comes with near-resonant Raman lasers [2]. We point out that our scheme can be implemented all optically through the use of a period-tripling superlattice, offering faster switching times and more precise control than with magnetic field gradients. Finally, we show that this method is very general for engineering novel single particle spectra in an optical lattice and can be used to map out Hofstadter's butterfly.

[1] H. Miyake, et al., Phys. Rev. Lett., 111, 185302
[2] C.J. Kennedy, et al., Phys. Rev. Lett., 111, 225301

Colin Kennedy
Massachusetts Inst of Tech-MIT

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