From Berry’s Phase to Wilson Lines in a Honeycomb Optical Lattice
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I will report on methods for fully characterizing the topology and geometry of Bloch bands in optical lattices. Using a Bose-Einstein condensate as a momentum-resolved probe, we study a paradigmatic model system, the honeycomb lattice. Its salient features are two Dirac points, each producing a half-quantum of Berry flux similar to the magnetic flux of an infinitesimally narrow solenoid. We have detected this singular Berry flux by forming an Aharonov-Bohm-type interferometer in momentum space. Our technique is broadly applicable to mapping out the Berry curvature or directly measuring the Chern number of a single band. I will furthermore show how interband dynamics can reveal the matrix-valued Wilson line, the generalization of Berry’s phase to the multi-band setting. In the simple case where the Wilson line is path-independent and Abelian, it serves as a powerful tool for tomographic reconstruction of the band eigenstates.