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Abstract for an Invited Paper
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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.[1] 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.[2] 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.

[1]L. Duca, T. Li, M. Reitter, I. Bloch, M. Schleier-Smith, and U. Schneider. *Science* **347**, 288 (2015).
[2]T. Li, L. Duca, M. Reitter, F. Grusdt, E. Demler, M. Endres, M. Schleier-Smith, I. Bloch, and U. Schneider. *arXiv*:1509.02185[cond-mat/quant-gas] (2015).