Abstract Submitted
for the DAMOP13 Meeting of
The American Physical Society

Direct Measurement of the Zak phase in Topological Bloch Bands
MONIKA AIDELSBURGER, MARCOS ATALA, Fakultaet fuer Physik, Ludwig-Maximilians-Universitaet, Munich, Germany, JULIO T. BARREIRO, Max-Planck Institute for Quantum Optics, Garching, Germany, DMITRY ABANIN, TAKUYA KITAGAWA, EUGENE DEMLER, Department of Physics, Harvard University, USA, IMMANUEL BLOCH, Max-Planck Institute for Quantum Optics, Garching, Germany — Geometric phases that characterize the topological properties of Bloch bands play a fundamental role in the modern band theory of solids. We report on the direct measurement of the geometric phase acquired by cold atoms moving in one-dimensional optical lattices. Using a combination of Bloch oscillations and Ramsey interferometry, we extract the Zak phase—the Berry phase acquired during an adiabatic motion of a particle across the Brillouin zone—which can be viewed as an invariant characterizing the topological properties of the band. For a dimerized optical lattice, which models polyacetylene, we measure a difference of the Zak phase equal to $0.97(2)\pi$ for the two possible polyacetylene phases with different dimerization. This indicates that the two dimerized phases belong to different topological classes, such that for a filled band, domain walls have fractional quantum numbers. Our work establishes a new general approach for probing the topological structure of Bloch bands in optical lattices.

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Date submitted: 25 Jan 2013 Electronic form version 1.4