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Observation of a dynamical topological phase transition in the non-equilibrium dynamics of ultracold quantum gases in driven optical lattices

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Ultracold atoms are a versatile system to emulate solid-state physics including the fascinating phenomena of gauge fields and topological band structures. By circular driving of a hexagonal optical lattice, we engineer the Berry curvature of the Bloch bands and realize a Haldane-like model. We have developed a full momentum-resolved state tomography of the Bloch states, which allows measuring the distribution of Berry curvature and obtaining the Chern number [1]. Furthermore, we study the time-evolution of the many-body wavefunction after a sudden quench of the lattice parameters and observe the appearance, movement, and annihilation of dynamical vortices in reciprocal space. We identify them as the Fisher zeros in the Loschmidt amplitude and define them as a dynamical equivalent of an order parameter, which suddenly changes its value at critical evolution times [2]. Our measurements constitute the first observation of a so-called dynamical phase transition and address the intriguing question of the relation between this phenomenon and the equilibrium phase transition in the system. [1] Flaeschner et al., Science 352, 1091 (2016). [2] Flaeschner et al., arXiv:1608.05616 (2016).