Detection of bulk topological features in real time

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Topological insulators are fascinating states of matter exhibiting protected edge states and robust quantized features in their bulk. Topological features are usually detected by means of transport measurements in systems with filled bands, or by direct imaging of the edge states. Here we show that the topological invariants characterizing one-dimensional chiral systems may be read out by performing a simple bulk measurement in real time [1]. To this aim, we introduce the mean chiral displacement, and we show analytically that this observable rapidly converges to the chiral winding. Then we discuss how periodically-driven (Floquet) systems are characterized by two windings, and we present experimental measurements of both invariants in a quantum walk with twisted photons. Combining the two windings allows us to retrieve the bulk-boundary correspondence, and to characterize the complete topological phase diagram of this system. Finally, we prove that the proposed detection is robust to spatial and temporal disorder. The method outlined here is extremely general, as it can be applied to all one-dimensional platforms simulating static or periodically-driven chiral systems.

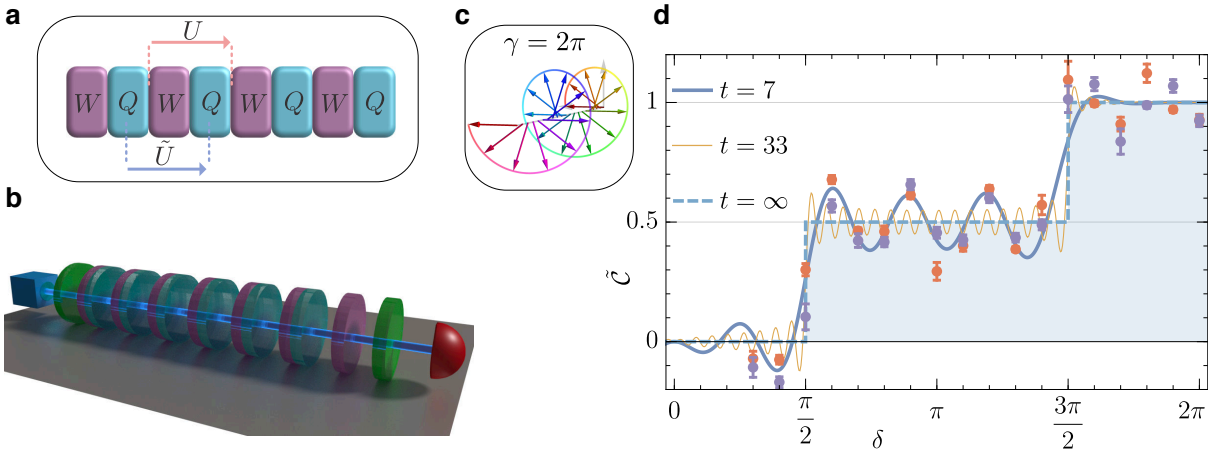

Figure 1. (a) Different choices of the time origin in a periodically-driven system lead to effective Hamiltonian with different windings. (b) Sketch of the experimental setup. (c) Winding of the effective Hamiltonian. (d) Experimental measurement of the mean chiral displacement (points) and analytical results (lines). In the long-time limit, the mean chiral displacement converges to the chiral winding (dashed line).

[1] F. Cardano, A. D'Errico, A. Dauphin, M. Maffei, B. Piccirillo, C. de Lisio, G. De Filippis, V. Cataudella, E. Santamato, L. Marrucci, M. Lewenstein, and P. Massignan, *Detection of Zak phases and topological invariants in a chiral quantum walk of twisted photons*, Nature Communications **8**, 15516 (2017).