Highlights

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Detection of Zak phases and topological invariants in a chiral quantum walk of twisted photons

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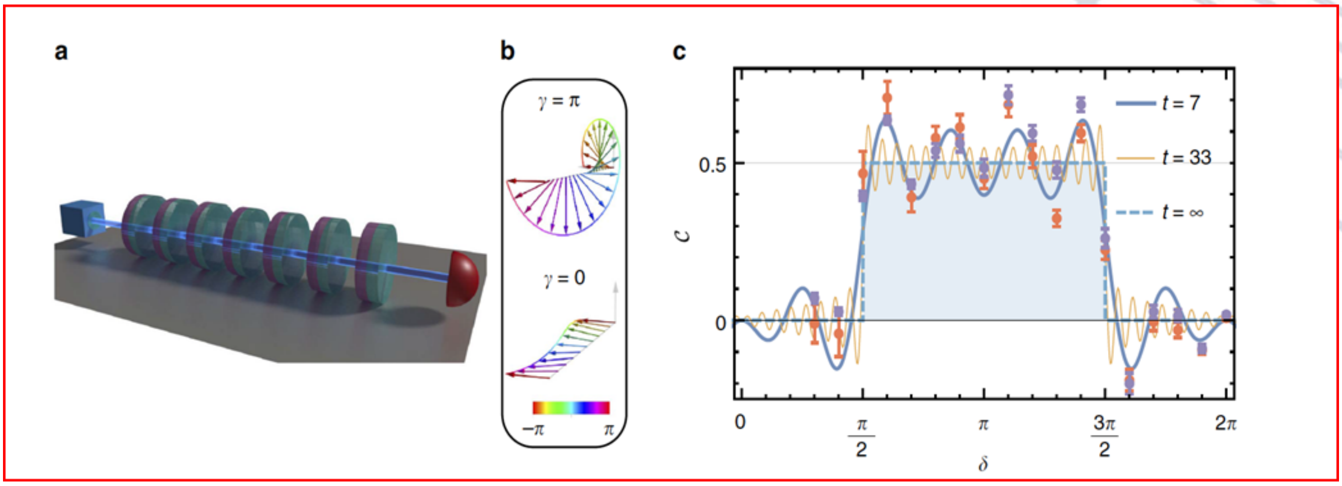
Topological insulators are fascinating states of matter exhibiting protected edge states and robust quantized features in their bulk. Here we propose and validate experimentally a method to detect topological properties in the bulk of one-dimensional chiral systems. We first introduce the mean chiral displacement, an observable that rapidly approaches a value proportional to the Zak phase during the free evolution of the system. Then we measure the Zak phase in a photonic quantum walk of twisted photons, by observing the mean chiral displacement in its bulk. Next, we measure the Zak phase in an alternative, inequivalent timeframe and combine the two windings to characterize the full phase diagram of this Floquet system. Finally, we prove the robustness of the measure by introducing dynamical disorder in the system. This detection method is extremely general and readily applicable to all present one-dimensional platforms simulating static or Floquet chiral.



Zak phase detection through the mean chiral displacement. (a) Sketch of the setup implementing the protocol U=Q*W. A light beam, exiting a single-mode fibre depicted on the left, performs a QW by propagating through a sequence of quarter-wave plates (purple disks) and q-plates (turquoise disks). (b) The unit vector n(k) winds either 1 or 0 times around the chiral axis, as k traverses the whole Brillouin zone, depending on the value of the optical retardation d. (c) Mean chiral displacement C after a 7-step QW of protocol U, versus the optical retardation δ. Each datapoint is an average over 10 different measurements (error bars are the associated s.e.). Purple and red dots refer, respectively, to different input polarizations, |L> and (|L>+|R>)/√2. The lines represent the subheading chiral term contained into the mean chiral displacement, for different values of the time t. In the long-time limit, it converges to (a multiple of) the Zak phase of protocol U.