Tracking the winding number of quenched quantum walks from bulk measurements

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Systems characterized by quantized and global features, known as topological invariants, can exhibit phenomena which are robust to smooth perturbations, like edge states and quantized electric or spin currents. Identifying the topological phase of a physical system can be achieved either by investigating those robust phenomena manifesting at the boundary of the system, or from direct measurements of the topological invariants. In this talk we will focus on the latter approach, specializing on how to retrieve the value of the topological invariant from bulk measurements of the single particle dynamics in one dimensional lattices. In these system, if sublattice symmetry is present, the topological invariant is known as winding number, an integer quantity associated with the topology of the energy spectrum. We will show that it is possible to ascertain the value of the winding number by measuring an observable called mean chiral displacement. The mean chiral displacement can be easily observed by looking at the single particle probability distributions on the different sublattices. We show our results in an experimental platform implementing a quantum walk in the spatial degrees of freedom of light, where the internal (or sublattice) degree of freedom is given by the polarization and the lattice is encoded by the orbital angular momentum or by the transverse wavevector. Interestingly our platform is also intrinsically periodic in time and thus it allows to investigate the richer topological features of periodically driven systems. In particular we reconstruct experimentally the full topological phase diagram of our system, identifying phases that are peculiar of periodically driven topological insulators. Moreover, we will show that the mean chiral displacement can converge to the topological invariant for a large class of states whose initial wavefunction is not necessarily localized. Remarkably, this implies that the mean chiral displacement can detect the winding number even when the underlying Hamiltonian is quenched between different topological phases. We confirmed these predictions in our platform by implementing different examples of quenched quantum walks.