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Topological Transition in a Non-Hermitian Quantum Walk: a new test for quantumness in driven artificial atoms and Josephson arrays

MARK RUDNER, Harvard University, LEONID LEVITOV, Massachusetts Institute of Technology — We analyze a quantum walk on a bipartite one-dimensional lattice, in which the particle can decay whenever it visits one of the two sublattices. The corresponding non-Hermitian tight-binding problem with complex potential for the decaying sites exhibits two distinct phases, distinguished by a winding number defined in terms of the Bloch eigenstates in the Brillouin zone [1]. We find that the mean displacement of a particle initially localized on one of the non-decaying sites is quantized as an integer, changing from zero to one at the critical point. By mapping this problem onto a Jaynes-Cummings-type model with decay, we find that the topological transition is relevant for a variety of experimental settings, in particular for superconducting qubits coupled to high quality resonators [2]. The quantized behavior stands in contrast with the smooth dependence expected for a classical random walk, and can serve as a hallmark of coherent quantum dynamics in ladder-like multilevel systems. A real-space implementation of the quantum walk may help to verify quantum coherence in vortex transport in Josephson arrays [3].
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