MAR15-2014-008774

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

Observation of topological transitions in interacting quantum circuits[1]

PEDRAM ROUSHAN, Google Inc., Santa Barbara, CA

Topology, despite its mathematical abstractness, often manifests itself in physics and plays a pivotal role in our understanding of natural phenomena. Notable examples include the discoveries of topological phases in condensed matter systems which have changed the modern conception of phases of matter. The global nature of topological ordering, however, makes direct experimental probing an outstanding challenge. Present experimental tools are mainly indirect and inadequate for studying such properties at a fundamental level. Here, we employ the exquisite control afforded by superconducting quantum circuits to directly investigate topological properties of quantum spin systems. The essence of our approach is to infer local curvature by measuring the deflection of quantum trajectories topological properties are then revealed from a quantum analog of the Gauss-Bonnet theorem. We benchmark our technique by constructing the topological phase diagram of the celebrated Haldane model. The nature of the individual phases is revealed by visualizing their microscopic spin texture and evolution across the transition. Furthermore, we demonstrate the power of our method in studying the topology of interacting quantum systems, utilizing a novel qubit architecture which enables control over every term in a two-qubit Hamiltonian. We discovered an interaction-driven topological phase, whose emergence is understood by fully exploring the parameter-space of the Hamiltonian. Our work establishes a generalizable experimental platform to study fundamental aspects of topological phenomena in quantum systems.

[1]NSF grants: DMR-0907039 and DMR-1029764