Bulk current flow in a quantum anomalous Hall insulator

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Theoretical and experimental studies suggest that the quantum anomalous Hall (QAH) system hosts a chiral edge mode (CEM) [1, 2, 3]. The general understanding in the field has been that non-equilibrium current—current flowing in response to applied source-drain bias—flows through the CEM. Here, we measure the potential at multiple locations in a QAH device while elevated temperature is used to induce nonzero but small longitudinal resistance. We show that the potential is well-described by solution of Laplace's equation. Our measurements imply that non-equilibrium current flows primarily through the two-dimensional bulk, not along the edge. Extrapolation suggests that this picture holds at even lower temperatures current where the resistance is vanishing [4].

While non-equilibrium current may not flow around the edges of a device, the CEM is expected to carry circulating persistent current. Yet persistent current is difficult to observe in transport measurements. We argue that persistent currents can be studied using emulations of Chern insulators created in Bosonic quantum simulators. Using numerical techniques, we show that chiral edge states can be created in Bosonic quantum simulators, and we study how edge states form persistent current.

References

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Figures

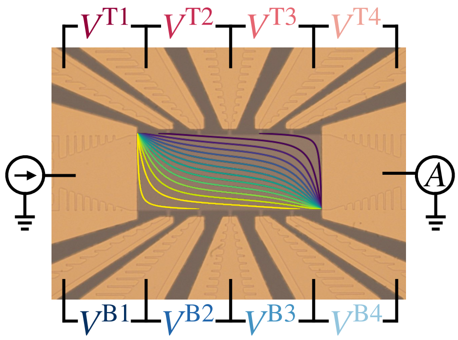

Figure 1: An optical micrograph of the QAH Hall bar studied in this work. Eight longitudinal resistance measurements are indicated. A solution of Laplace's equation is superimposed on the Hall bar, matching resistance measurements.

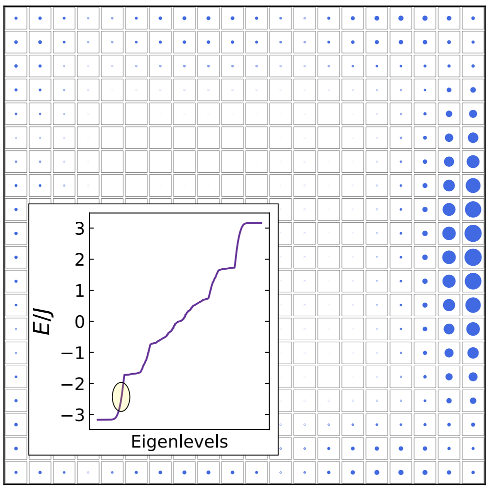

Figure 2: A single-photon chiral edge wavepacket in a simulation of a 20-by-20 qubit Chern lattice, constructed as a superposition of 8 edge states. The size of the blue dots represents the population on each site. *Inset*: The eigenspectrum of the qubit lattice. The states from which the wavepacket is constructed are highlighted in yellow.