Topological Robustness Revealed by Real-time Longitudinal and Transverse Studies

Anh Ho Hoai[1], Jian Huang[1], Loren Pfeiffer[2] and Ken West[2]

[1] *Department of Physics, Wayne State University, Detroit, MI, USA 48201*

[2]*Department of Electrical Engineering, Princeton University, Princeton, NJ, USA*

jianhuang@wayne.edu

What factors contribute to the robustness of topology? This inquiry confronts most topology-themed studies wherein the level of protection examined in various systems is ubiquitously variable and system-dependent. The discrepancies are often reflected in variations in the precision levels. For example, it remains puzzling why the integer quantum Hall effect (IQHE) hosted in graphene exhibits substantially lower precision than in GaAs two-dimensional systems despite similar disorder levels. On a related note, why do some protected states break down much easier than others? It is evident that these questions concern mechanisms pertinent to specific system conditions (i.e. disorder and electron-electron interaction) and cannot be addressed solely by the general notion of backscattering-preventing symmetries [1], i.e. chiral modes in quantum Hall and quantum anomalous Hall effects and time-reversal symmetry (in the presence of spin-orbit coupling) for quantum spin Hall and topological insulators. So far, extensive investigations have focused on dissipation effects of edge states due to locally distorted energy bands by disorders. Despite the various insights on local reconstruction and coherences revealed on microscopic scales [2], the results based on longitudinal modes alone appear insufficient. Meanwhile, the transverse contribution, shown by breakdown studies [3] as to leveraging bulk reconstruction, needs to be further explored.

This study investigates the real-time connection between longitudinal and transverse contributions influencing the breakdown of an IQHE [4]. Utilizing a Corbino sample geometry hosting an IQHE brought to the verge of a breakdown, detection of dissipation is independently performed in longitudinal and transverse directions simultaneously, while measuring metallic and insulating responses by two separate setups on distinct frequency bands. A one-to-one correspondence in time domain, as shown by the Hall and bulk dissipation in Fig.1, indicates that dissipationless modes possess both longitudinal and transverse degrees of freedom. The results to be presented support the following: 1. Like Büttiker's impurity scattering picture of preserving chiral edge modes, transverse reconstructions also preserve chiral modes as they reroute globally through a mechanism of local resonances. This delineates a different scenario envisioned in the TKNN model [5]. 2. The ability to reconstruct while preserving overall transverse insulation is where robust protection derives. 3. Because electron-electron interaction drastically influences reconstruction through impurity screening, it enhances protection. The reconstructive concept qualitatively explains the discrepancies in robustness levels. Lastly, reconstructed chiral current paths are natural bulk probes to energy structures including when modified by electron correlation [5].

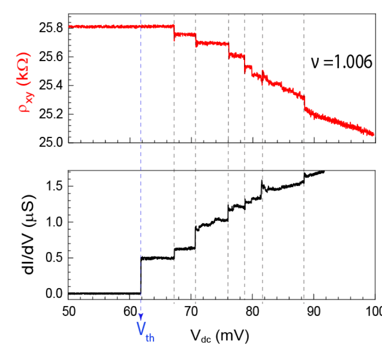

Fig.1. Time-domain correspondence of bulk dissipation and deviations from Hall quantization.

We would prefer an oral presentation in either category 7. Topological states of matter, topological Insulators, and Weyl semimetals, or category 9. Quantum Hall effect, and fractional quantum Hall effect. We would also ask the committee to consider the possibility of increasing presentation time, given the number of results to be shared.

References

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