Are symmetry protected topological states immune to dephasing?

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The hallmark of topology in condensed matter systems are their topological phases in featuring symmetry protected dissipation-less channels. Symmetry protection can give rise to different kinds of topological channels which include, for instance, the quantum spin Hall (QSH) phase, the spin quantum anomalous Hall (SQAH) phase. It remains to be seen whether these states are indeed robust to dephasing effects, and if so, to what degree. Effectively harnessing topological phases and phase transitions is essential in topological electronics.

This work is devoted to the robustness of these topological phases in the backdrop of the topological quantum field effect transition in buckled 2D-Xenes (Ref [1], [2]).The topological transitions involving the quantum spin Hall (QSH) to quantum valley Hall (QVH) and spin quantum anomalous Hall (SQAH) to quantum anomalous valley Hall (QAVH) are studied in detail. We study the effects of dephasing and disorder in the channel on both regimes' ON state. We employ the phenomenological dephasing model using the non-equilibrium Green's function (NEGF) technique [3]. We also explicitly add impurity potentials in the channel and average over hundreds of configurations for the same bandgap in the QSH and the SQAH phases. The results indicate stark robustness: the worst-case drop in conductance for very reasonable dephasing ranges is 0.35% for the QSH ON state and 0.06% for the SQAH ON state.

References

[1] Ezawa et al., Physical Review B, 15 (2013) 155415
[2] Sagnik Banerjee et al., Physical Review Applied, 5 (2022) 054088
[3] S. Datta, Lessons from Nanoelectronics (World Scientific, Singapore, 2018), 2nd ed

Figures

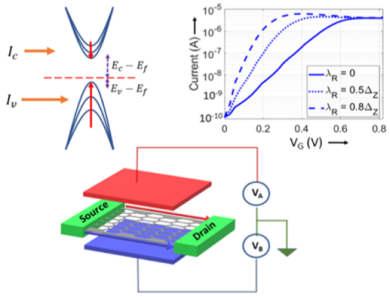

Figure 1: Quantum Field Effect Transistor with dissipation-less ON-state (Ref [2])

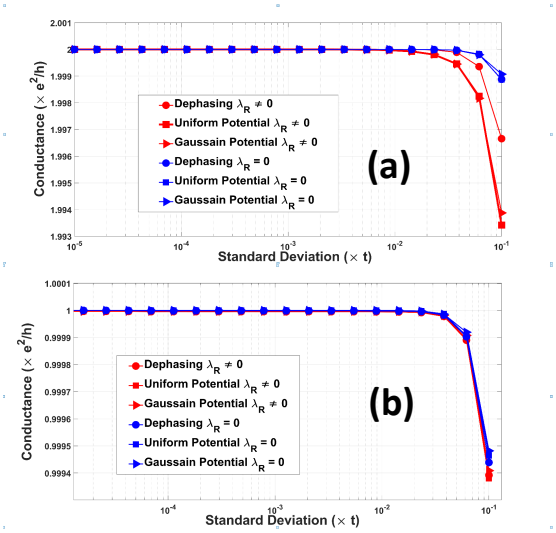

Figure 2: Effect of dephasing and disorder in the channel in the (a) QSH and (b) SQAH phases

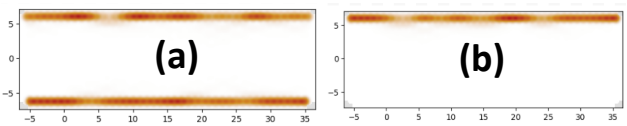

Figure 3: Wavefunction densities under disorder in the (a) QSH and the (b) SQAH phases