Control of edge modes in magnetic topological insulators with normal and superconducting gates

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Topological insulator materials are an excellent platform for emergent edge modes. Quantum spin Hall modes appear in a time-reversal scenario, whereas quantum Hall modes (in a magnetic field) and quantum anomalous Hall modes (with intrinsic magnetization) form when this symmetry is broken. Furthermore, Majorana edge modes and Majorana bound states are theoretically predicted to emerge when these materials become superconducting through proximity hybridization with nearby conventional superconductors.

In this contribution, we discuss the use of electrostatic gates to manipulate the formation of edge modes in MTI's. This builds upon our previous investigations. Specifically, we demonstrate how an electrostatic gate can create a tunable electrostatic border as opposed to a vacuum border. Combining these two types of borders allows for the manipulation of QAH and QSH edge modes which are predicted to emerge in double-junction scenarios. We find large renormalizations of the mode velocities.

When we incorporate superconductivity into our model, we examine the case of an MTI slab containing two sequential regions with superconductivity. Specifically, we show that remarkable resonances emerge as the phase difference between the two superconductors is varied. Additionally, we develop an analytical scattering matrix in the presence of a single Majorana edge mode. This model can be extended to a multiterminal setup. Lastly, we discuss the importance of mode velocity renormalization caused by the electrostatic gate in the superconducting context.

References

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