

Interference of chiral Majorana modes in Magnetic Topological Insulators with electrostatic gating.

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We research the interference effects of chiral Majorana modes in a magnetic topological insulator thin slab combining superconducting proximity and electrostatic gating. The system (shown in Fig. 1) consists of a grounded superconducting-proximitized section and a gated section that locally opens an energy gap and mediates the coupling between quantum anomalous Hall (QAH) edge states in the leads and chiral Majorana modes in the superconducting region.

We show that local and nonlocal conductances show transport signatures due chiral Majorana physics. In the Majorana phase, local conductances at the two terminals exhibit pronounced oscillatory resonances as a function of the gate-induced gap strength, originating from resonant coupling to localized states in the gated region. These resonances can exceed e^2/h and display correlated or anti-correlated behavior depending on the total length of the proximitized section L_S .

Nonlocal conductances generally vanish; however, when the chemical potential is tuned away from zero, an asymmetric nonlocal response emerges, leading to a gate-tunable Majorana diode effect. For strong gating, an electrical cutoff regime is reached in which the terminals are effectively disconnected. In this regime, the right local conductance shows large

oscillations between 0 and $2e^2/h$ as a function of the length of the non-gated region $\ell+L_S$, while all other conductances are suppressed.

Based on these features, we propose an experimentally feasible protocol to identify chiral Majorana modes using multiple electrostatic gates. In contrast, in the two-Majorana (fermionic) phase, transport is dominated by a propagating QAH mode, yielding identical local conductances that do not exceed e^2/h and vanish in the cutoff regime. Our results demonstrate that electrostatic gating offers a powerful tool to control and detect chiral Majorana interference in QAH-superconductor hybrid systems.

Figures

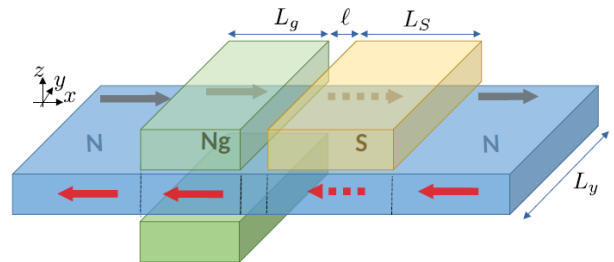


Figure 1: Schematic of an MTI thin slab (blue) with a proximitized superconducting sector (S, superconductor in yellow) and a normal gated section (Ng, top/bottom electrodes in green). The arrows qualitatively indicate transport by chiral edge Fermionic (solid) and Majorana (dashed) modes in different sectors of the slab. The figure also shows the definitions of the transverse width (L_y) and the lengths of the proximitized (L_S), gated (L_g) and separation (ℓ) distances along the slab.

References

- [1] Javier Osca and Llorenç Serra. Phys. Rev. B 112, 224519 (2025)