

# Majorana Modes Break Voltage Gauge Invariance in NSN Junctions of Magnetic Topological Insulators

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Magnetic topological insulators (MTIs) are outstanding candidates for the realization of topological 1D and 2D superconducting phases [1,2], which can host end-localized or propagating Majorana modes. However, experimental detection of these elusive modes is still a matter of concern [3].

We propose to detect such topologically-protected edge states in a NSN junction between normal and proximitized MTIs by applying an asymmetric bias on the two normal leads of the device.

Without Majorana modes in the superconducting sector, the conductance is independent of the way the total voltage drop is distributed across the junction.

We refer to this physical property as "gauge invariance" of the electric current in the NSN junction, and we argue that the emergence of Majorana states in the condensate breaks the invariance.

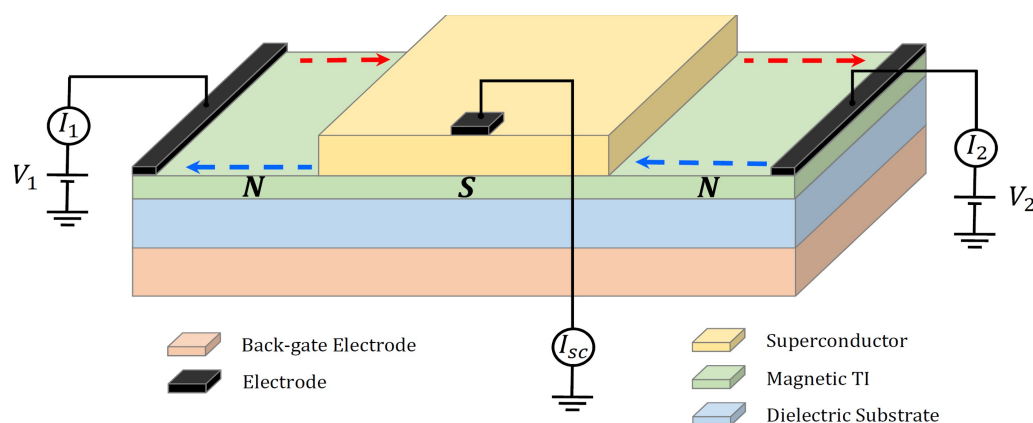
Indeed, in the presence of Majorana states and with an unbalanced bias, the electric current is not symmetrical on the two sides of the device, and the charge conservation implies a Cooper pair current from the superconductor to ground.

This electric current, which can be easily measured in a real device, is a characteristic signal of zero-energy Majorana quasiparticles and can be used for their experimental detection.

## References

- [1] Jing Wang, Quan Zhou, Biao Lian and Shou-Cheng Zhang, *Chiral topological superconductor and half-integer conductance plateau from quantum anomalous Hall plateau transition*, Phys. Rev. B **92**, 064520 (2015).
- [2] Yongxin Zeng, Chao Lei, Gaurav Chaudhary and Allan H. MacDonald, *Quantum anomalous Hall Majorana platform*, Phys. Rev. B **97**, 081102(R) (2018).
- [3] Morteza Kayyalha et al., *Absence of evidence for chiral Majorana modes in quantum anomalous Hall-superconductor devices*, Science **367**, 64-67 (2020).

## Figures



**Figure 1:** Proposed experimental setup for the detection of topologically-protected Majorana edge modes in a magnetic topological insulator.