Field-Effect Josephson Diode with Anisotropic Spin-Momentum Locking States

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Abstract

The recently observed superconducting diodes generalized the conventional electronic nonreciprocal phenomenon category to a superconducting regime. We theoretically propose a topological Josephson diode, whose topologically protected maximal efficiency is 40% in a single edge and greatly optimized to 90% in a double-edge interferometer. As a transistor, the diode can be switched on/off, and its polarity can be reversed by controlling the gate voltage. The proposal fusing topological materials, superconductivity, and nonreciprocity may have a potential application in topologically superconducting electronics.

References

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Figures

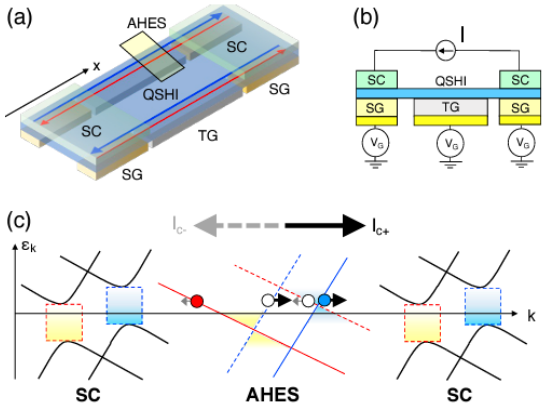

Figure 1: (a)Schematic of a topological Josephson diode (TJD) of quantum spin Hall insulator (QSHI) with anisotropic helical edge states (AHESs). The superconducting (SC) leads and the central normal region are controlled by the super gates (SGs) and the tunneling gate (TG), respectively. (b) A side view of TJD. (c) Schematic dispersions of the top edge states in the normal (central) and superconducting region.

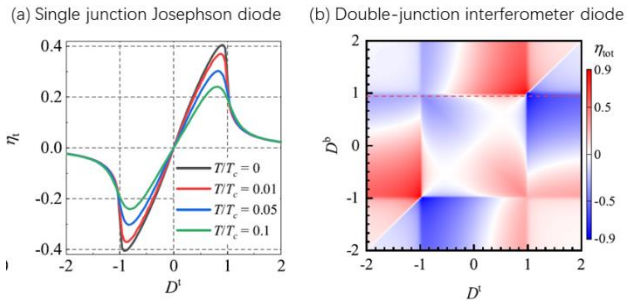

Figure 2: (a) Diode efficiency in a single edge via the electrically induced super gate. (b) Diode efficiency in a two-edge interferometer via the super gates in two edges.

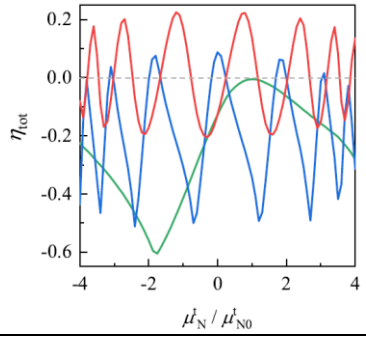

Figure 3: A Josephson diode transistor controlled by a tunneling gate.