Supercurrent interference in HgTe-wire Josephson junctions

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Wires made of topological insulators (TI) are a promising platform for searching for Majorana bound states. These states can be probed by analyzing the fractional ac Josephson effect in Josephson junctions with the TI wire as a weak link [1]. An axial magnetic field can be used to tune the system from trivial to topologically nontrivial [2]. Here we investigate the oscillations of the supercurrent in such wire Josephson junctions as a function of the axial magnetic field strength and different contact transparencies. Although the current flows on average parallel to the magnetic field we observe h/2e, h/4e- and even h/8e-periodic oscillations of the supercurrent in samples with lower contact transparencies. Corresponding tight-binding transport simulations using a Bogoliubov-de Gennes model Hamiltonian yield the supercurrent through the Josephson junctions, showing in particular the peculiar h/4e-periodic oscillations observed in experiments. A further semiclassical analysis based on Andreev-reflected trajectories connecting the two superconductors allows us to identify the physical origin of these oscillations. They can be related to flux-enclosing paths winding around the TI-nanowire, thereby highlighting the three-dimensional character of the junction geometry compared to common planar junctions.

References

[1] R. Fischer, J. Picó-Cortés, W. Himmler, G. Platero, M. Grifoni, D. A. Kozlov, N. N. Mikhailov, S. A. Dvoretsky, C. Strunk, and D. Weiss, 4π-periodic supercurrent tuned by an axial magnetic flux in topological insulator nanowires, Phys. Rev. Res. 4, 013087 (2022)
[2] A. M. Cook, M. M. Vazifeh, and M. Franz, Stability of Majorana fermions in proximity-coupled topological insulator nanowires, Phys. Rev. B 86 (2012)

Figures

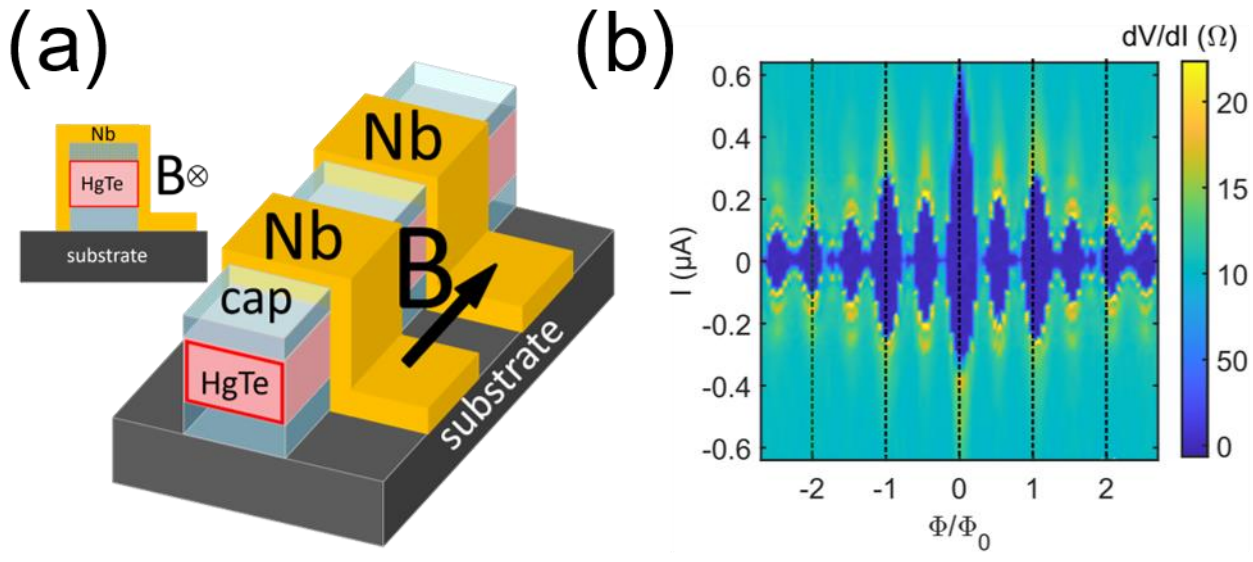

Figure 1: (a) Sample geometry: CdTe/HgTe/CdTe nanowire contacted by superconducting Nb leads. (b) Oscillations of the critical current w.r.t. the axial magnetic flux penetrating the wire.