Revealing topological hinge states in the second order topological insulator Bi4Br4

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Résumé

Topological Insulators (TIs) hold great promise for making novel electronic devices, thanks to the existence at their boundaries of topologically protected conduction channels. Unfortunately, the expected protection has turned out to be less robust than anticipated, notably due to inelastic processes involving bulk excitations. This complicates the fundamental study of the edge states, and motivates the search for different TIs with a reduced contribution of the non-topological bulk states. Among newly discovered TIs, Bi4Br4 appears to be a very promising material, with a large bulk gap (_˜ 230 meV), and experimental indications of a Second Order Topological Insulator (SOTI) character. SOTIs are topological insulators with (d-2)-dimensional topological states, d being the dimension of the bulk. Indeed, 1D states were evidenced by ARPES and visualized by STM at the hinges of a Bi4Br4 crystal, persisting up to 300K. Our work has been focused on evidencing these hinge states in low-temperature transport experiments by investigating the modulation of quantum interferences with magnetic field and gate voltage. We have found signatures of phase coherence in μm-sized samples with surprisingly large characteristic fields, and a strongly anisotropic behavior. These results suggest that transport in the Bi4Br4 flakes is mediated by 1D ballistic channels, which scatter only in the region under the metallic electrodes. STEM/EDX experiments on FIB lamellae are underway, and should shed light on the morphology of the contact/Bi4Br4 interface. To better evidence the topological 1D edge states, we turned to superconducting contacts. Indeed, because they are ballistic, topological states can carry large supercurrents when proximitized with superconducting electrodes, hence magnifying their signatures in transport. We find sizeable supercurrents in S-Bi4Br4-S Josephson junctions that persist up to extremely high fields (several Teslas), and switching histograms with strong dynamical effects. Our results thus support the SOTI nature of Bi4Br4.

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