Transport of spin-chiral Dirac fermions in Bi2Se3 nanostructures

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Abstract

Recently discovered Z2 topological insulators (TIs) are ideally conducting at their interface only, where a gapless band structure forms. In a strong 3D TI, such as Bi2Se3, surface states are spin-chiral Dirac fermions with an odd number of Dirac cones. This property makes them robust against non-magnetic perturbations (topological protection due to a spin Berry phase), and the electrical transport of Dirac fermions can therefore be easily studied in nanostructures even in presence of a strong disorder. However, in real materials, the finite bulk conductivity often prevents the study of surface-state transport.

We show that mesoscopic transport measurements can unambiguously reveal the specific properties of spin-chiral Dirac fermions in a Bi2Se3 nanostructure [1]. The quantum conductance of a nanowire exhibits Aharonov-Bohm oscillations which result only from surface-state transport. At very low temperatures, the temperature dependence of their amplitude unveils the quasi-ballistic nature of charge transport, which is the signature of the weak coupling of quasi-particles to their environment. Our results further reveal the weak scattering by structural disorder, giving another evidence of the specific nature of spin-chiral Dirac fermions in a strong 3D TI.

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