Researchers demonstrate and explain surface conduction in a topological insulator

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(Phys.org) -- Researchers at the University of Maryland and the NIST Center for Nanoscale Science and Technology have for the first time experimentally demonstrated surface-only charge conduction in a topological insulator [1], and have theoretically explained the conduction using techniques previously applied successfully to the understanding of graphene [2].

The research team found that the thin Bi_2Se_3 crystals studied have unusual magneto-electronic properties that should allow such topological insulators to be used in new types of devices, including high-performance transistors, magnetic sensors, and optical detectors.

A topological insulator is an unusual type of three-dimensional material theoretically predicted to carry electric charge only on a two-dimensional boundary.

As recently verified by experiment, topological insulators behave as an electrical insulator in their interior but conduct electrons on their surface.

Topological insulators have also been predicted to have an unusual Dirac-type electronic band structure (shared by graphene), where the electron energy has a linear dependence on momentum, as seen in photons.

By directly measuring the charge transport on the surface of thin Bi2Se3 crystals, the researchers showed that the behavior at the surface is consistent with a Dirac band in which the electrons are weakly interacting and disordered.

These features of the Dirac band imply that, unlike graphene, the conducting electrons at the surface of topological insulators have a unique coupling between their spins and charges.

This coupling could give rise to new kinds of solid state devices, including smaller magnetic components whose logic can be switched using nanoscale spin currents.

More information: 1. Surface conduction of topological Dirac electrons in bulk insulating Bi2Se3, D. Kim, S. Cho, N. P. Butch, P. Syers, K. Kirshenbaum, S. Adam, J. Paglione, and M. S. Fuhrer, Nature Physics 8, 460-464 (2012).

2. Two-dimensional transport and screening in topological insulator surface states, S. Adam, E. H. Hwang, and S. Das Sarma, Physical Review B 85, 235413 (2012).

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