Bismuth shows novel conducting properties

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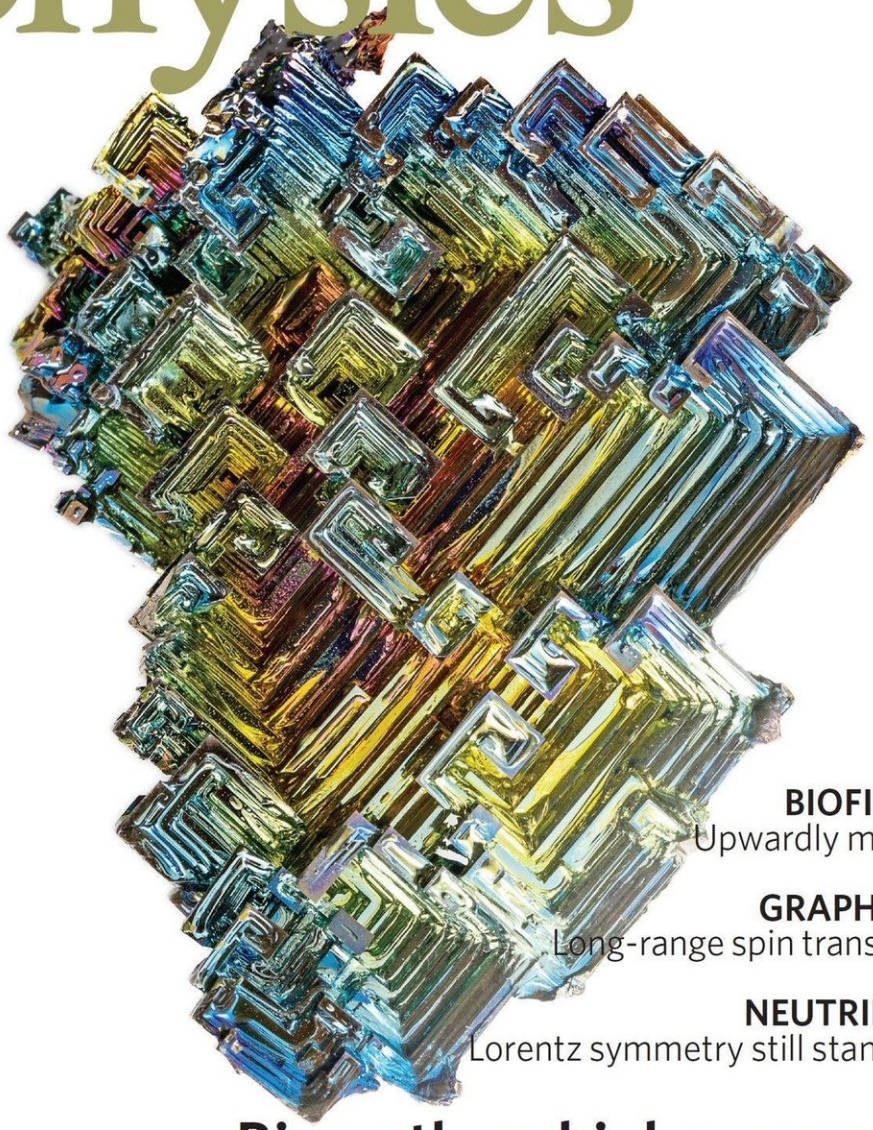

BIOFILMS
Upwardly motile

GRAPHENE
Long-range spin transport

NEUTRINOS
Lorentz symmetry still standing

Bismuth on higher ground

A team of international scientists including Maia G. Vergniory, Ikerbasque researcher at DIPC and UPV/EHU associate, has discovered a new class of materials, higher-order topological insulators. Theoretical physicists first predicted the existence of these insulators, which have conducting properties on the edges of crystals rather than on their surfaces, and conduct electricity without dissipation. Now, these novel properties are demonstrated experimentally in bismuth.

The current flows without resistance and responds in unconventional ways to electric and magnetic fields. These unique properties have future applications in high-performance electronics and quantum computation.

Higher-order topological insulators

Recently, a new class of topological materials with novel conducting properties was predicted by a group of physicists from Donostia International Physics Center (DIPC), the University of the Basque Country (UPV/EHU), UZH, Princeton University and Max Planck Institute of Microstructure Physics. The researchers refer to it as a "higher-order topological insulator."

According to theoretical studies, the conducting edges are extraordinarily robust for higher-order topological insulators. The current of topological electrons cannot be stopped by impurities, and if the crystal breaks, the new edges automatically also conduct current. However, the most extraordinary property of these new materials is that they can theoretically conduct electricity without any dissipation, as superconductors do at low temperatures. This would be a specific property of higher-order class topological insulators.

Bismuth is topological

Now, it has been confirmed that bismuth, an element consistently described as bulk topologically trivial, follows a generalized bulk-boundary correspondence of higher-order, that is, hinges have topologically protected conducting modes instead of the surface of the crystal.

The special topological properties of this element were first identified by using symmetry arguments, topological indices, first-principles calculations, and the recently introduced framework of topological quantum chemistry.

This phenomenon was then verified experimentally. With scanning-tunneling spectroscopy, the unique signatures of the rotational symmetry of the one-dimensional states located at step edges of the crystal surface were proved. Using Josephson interferometry, scientists demonstrated their universal topological contribution to the electronic transport.

Finally, this work establishes bismuth as a higher-order topological insulator and opens the way to identify new ones.

More information: Frank Schindler et al. Higher-order topology in bismuth, *Nature Physics* (2018). DOI: 10.1038/s41567-018-0224-7

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