Researchers present new multifunctional topological insulator material with combined superconductivity

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Most materials show one function, for example, a material can be a metal, a semiconductor, or an insulator. Metals such as copper are used as conducting wires with only low resistance and energy loss. Superconductors are metals which can conduct current even without any resistance, although only far below room temperature. Semiconductors, the foundation of current computer technology, show only low conduction of current, while insulators show no conductivity at all. Physicists have recently been excited about a new exotic type of materials, so-called topological insulators.

A topological insulator is insulating inside the bulk like a normal insulator, while on the surface it shows conductivity like a metal. When a topological insulator is interfaced with a superconductor, a mysterious particle called Majorana fermion emerges, which can be used to fabricate a quantum computer that can run much more quickly than any current computer. Searching for Majorana fermions based on a topological insulator–superconductor interface has thus become a hot race just very recently.

Computer-based materials design has demonstrated its power in scientific research, saving resources and also accelerating the search for new materials for specific purposes. By employing state-of-art materials design methods, Dr. Binghai Yan and his collaborators from the Max Planck Institute for Chemical Physics of Solids and Johannes Gutenberg

University Mainz (JGU) have recently predicted that the oxide compound $BaBiO_3$ combines two required properties, i.e., topological insulator and superconductivity. This material has been known for about thirty years as a high-temperature superconductor of Tc of nearly 30 Kelvin with p-type doping. Now it has been discovered to be also a topological insulator with n-type doping. A p-n junction type of simple device assisted by gating or electrolyte gating is proposed to realize Majorana fermions for quantum computation, which does not require a complex interface between two materials.

In addition to their options for use in quantum computers, topological insulators hold great potential applications in the emerging technology of spintronics and thermoelectrics for energy harvesting. One major obstacle for widespread application is the relatively small size of the bulk band gap, which is typically around 0.3 electron-volts (eV) for previously known topological insulator materials. Currently identified material exhibits a much larger energy-gap of 0.7 eV. Inside the energy-gap, metallic topological surface states exist with a Dirac-cone type of band structures.

The research leading to the recent publication in *Nature Physics* was performed by a team of researchers from Dresden and Mainz around the theoretical physicist Dr. Binghai Yan and the experimental chemists Professor Martin Jansen and Professor Claudia Felser. "Now we are trying to synthesize n-type doped $BaBiO_3$," said Jansen. "And we hope to be soon able to realize our idea."

More information: Binghai, Y., Jansen, M. and Felser, C. A large-energy-gap oxide topological insulator based on the superconductor BaBiO3, *Nature Physics*, 22 September 2013. DOI: 10.1038/nphys2762

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