PRESS RELEASE

Controlling electron spins by light

Researchers of HZB manipulate the electron spin at the surface of topological insulators systematically by light

Berlin, 27 March 2014

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Topological insulators are considered a very promising material class for the development of future electronic devices. A research team at Helmholtz-Zentrum Berlin (HZB) has discovered, how light can be used to alter the physical properties of the electrons in these materials. Their results have just been published by the renowned journal "Physical Review X" (DOI: http://dx.doi.org/10.1103/PhysRevX.4.011046)

The material class of topological insulators has been discovered a few years ago and displays amazing properties: In their inside, they behave electrically insulating but at their surface they form metallic, conducting states. The electron spin, i. e., their intrinsic angular momentum, is playing a decisive role. Their sense of rotation is directly coupled to their direction of movement. This coupling leads not only to a high stability of the metallic property but also enables a particularly lossless electrical conduction. Topological insulators are, therefore, considered interesting and promising candidates for novel devices in information technology.

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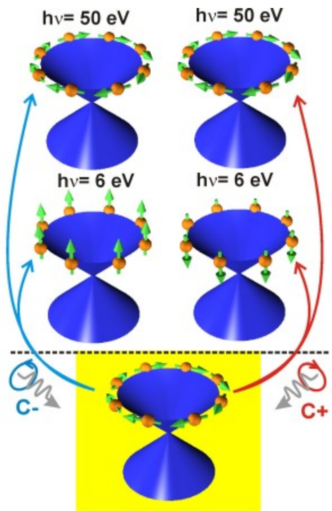

The picture shows the characteristic spin texture (arrows) in a topological insulator (bottom) and how it is either probed by circularly polarized light (top) or manipulated by it (middle). Picture: Rader/Sachez-Barriga/HZB

A particularly innovative approach is to try and influence the electron spin at the surface in such devices by light. HZB researcher Prof. Oliver Rader and his team have discovered by which means the spin at the surface of topological insulators can be altered. To this end, the researches performed experiments with light of various energies or wavelengths.

The wavelenght counts

At the synchrotron radiation source BESSY II they investigated the topological insulator bismuth selenide (Bi_2Se_3) using a method called "spin-resolved photoelectron spectroscopy" – and gained astonishing insights: They found an astonishing difference depending on whether the electrons at the surface of the material are excited with circularly polarized light in the vacuum ultraviolet (50-70 electron volts, eV) or in the ultraviolet spectral range (6 eV).

They could demonstrate that they can measure the spin of the electrons without changing it at higher energies which are typically used at synchrotron light sources. "When excited at 50 eV, the emitted electros display the typical spin texture of topological insulators", Dr. Jaime Sánchez-Barriga, who conducted the experiments, explains. "The electron spins are in the surface aligned on a circle, similarly to a traffic sign for roundabout." This is the ground state of the electrons in the surface of topological insulators."

When excited by low-energy circularly polarized photons (6 eV), the spin of the electrons moved completely out of the surface plane. Above all, they adopted the spin orientation imposed by the right- or left-circularly polarized light. This means that the spin can be systematically manipulated – depending on the light that is used. The scientists can also explain the entirely different behavior at different energies which they attribute to symmetry properties. "Our result delivers important insight how lossless currents could be induced in topological insulators", Oliver Rader explains. "This is important for the development of so-called optospintronic devices which could enormously enhance the speed at which information is stored and processed."

DFG Priority Program

Due to the high potential promised by topological insulators, the German Research Foundation DFG initiated the Priority Program „Topological Insulators: Materials – Fundamental Properties – Devices“. Prof. Rader coordinates this program which aims at an improved understanding of the physics of the surface states in topological insulators.

Publication: Photoemission of Bi_2Se_3 with Circularly Polarized Light: Probe of Spin Polarization or Means for Spin Manipulation? Phys. Rev. X 4, 011046 – Published 24 March 2014; J. Sánchez-Barriga, A. Varykhalov, J. Braun, S.-Y. Xu, N. Alidoust, O. Kornilov, J. Minár, K. Hummer, G. Springholz, G. Bauer, R. Schumann, L. V. Yashina, H. Ebert, M. Z. Hasan, and O. Rader.

The **Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)** operates and develops large scale facilities for research with photons (synchrotron beams) and neutrons. The experimental facilities, some of which are unique, are used annually by more than 2,500 guest researchers from universities and other research organisations worldwide. Above all, HZB is known for the unique sample environments that can be created (high magnetic fields, low temperatures). HZB conducts materials research on themes that especially benefit from and are suited to large scale facilities. Research topics include magnetic materials and functional materials. In the research focus area of solar energy, the development of thin film solar cells is a priority, whilst chemical fuels from sunlight are also a vital research theme. HZB has approx.1,100 employees of whom some 800 work on the Lise-Meitner Campus in Wannsee and 300 on the Wilhelm-Conrad-Röntgen Campus in Adlershof.

HZB is a member of the Helmholtz Association of German Research Centres, the largest scientific organisation in Germany.