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Max-Planck-Institut für Intelligente Systeme
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Visualizing Helical Metals on the Surface of Topological Insulators

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Abstract

Soon after the discovery of quantum mechanics it was realized why some solids are insulating (like diamond) and others are highly conducting (like graphite), even though they could be comprised of the same element. Now, 80 years later, the concept of insulators and metals is again being fundamentally revised. During the last few years, it has become apparent that there can be a distinct type of insulator, which can occur because of the topology of electronic wavefunctions in materials comprised of heavier elements. Strong interaction between the spin and the orbital angular momentum of electrons in these compounds alters the sequence in energy of their electronic states. The key consequence of this topological characteristic (and the way to distinguish a topological insulator from an ordinary one) is the presence of metallic electrons with helical spin texture at their surfaces. I will describe experiments that directly visualize these novel quantum states of matter and demonstrate their unusual properties through spectroscopic mapping with the scanning tunneling microscope (STM). These experiments show that the spin texture of these states protects them against backscattering and localization. [1] These states appear to penetrate through barriers that stop other electronic states. [2,3] I will also describe more ongoing efforts focused on unraveling the physics of topological surface states and their potential applications for the realization of other exotic quantum states, such as Majorana fermions.

References:
[1] Roushan et al. Nature 460 1106 (2009).
[2] Seo et al. Nature, 466 434 (2010).
[3] Beidenkpof et al. Nature Physics, (2011).