Transport Studies of Topological Insulators

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A topological quantum state of matter is characterized by a nontrivial topological structure of its Hilbert space. Intriguingly, a topological state is always accompanied by a peculiar gapless edge/surface state that characterizes the nature of the bulk state. A well-known example is the 2D quantum Hall state, which is accompanied by chiral edge states to represent the nontrivial topology of the bulk state specified by the topological invariant called Chern number. In 3D topological insulators, on the other hand, a nontrivial Z_2 topology of the bulk state leads to the emergence of helical Dirac fermions on the surface, which hold promise for various novel applications.

However, transport studies of the helical Dirac fermions on the surface turned out to be difficult, because unwanted transport through the bulk state needs to be suppressed before the surface transport becomes accessible. Therefore, syntheses of new bulk-insulating materials and/or high-quality samples [1-6] have been crucially important for elucidating their peculiar physics [7-10]. Besides such transport studies, syntheses of new or high-quality topological materials have been fruitful for exploring peculiar quantum phenomena in those materials [11-22]. In this talk, I will present some of the breakthroughs we have made in this new frontier of quantum materials.

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