Spin-orbit interaction and topological phase in atom-thin layers

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Three dimensional (3D) topological insulating (TI) state, in which the bulk is insulator with an energy band gap while the surface is gapless conductor, has been reported in some materials and attracted significant attention. On the other hand, 2D TI states have been experimentally reported only in few materials, such as quantum wells of HgTe/CdTe or InAs/GaSb. In 2D TI state, quantum SHE (QSHE) is observed with a bulk energy gap but gapless helical edge states protected by time reversal symmetry, in which opposite spin states forming a Kramers doublet counterpropagate. Although 2D TI states are theoretically predicted for graphene, atomically thin 2D carbon layer, experimental observation is rare. On the other hand, atom-thin transition-metal di-chalcogenide (TMDC) layers are attracting significant attention from various viewpoints. It has been recently predicted that 1T'-phase of such layers can be within 2D TI states due to the band inversion. Thus, it is indispensable to realize 2D and 1D TI states in various atom-thin materials.

For the creation of TI states, introduction of spin-orbit interactions (SOIs) is crucial. Recently, challenge of introduction of SOI into graphene has been experimentally reported by some methods [e.g., surface decoration by (1) right-mass adatoms or (2) heavy nanoparticles, and (3) using heavy substrates]. In the talk, I will present (1) and (2) using small-amount of hydrogen atoms and Pt or Bi_2Te_3 nanoparticles, respectively, which result in introduction of large SOI gaps and subsequent emergence of the 2D TI states. Moreover, I will present that 1T' phase of MoS_2, one of TMDC family, which is created by laser beam irradiation, can be within the 2D TI states. These observation must open doors to 2D topological phases of graphene and atom-thin TMDCs and those application to low-power and voltage-controlled spintronic devices.



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