All-electrical control of Dirac electron transport (LT26)

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All-electrical manipulation of electron spin in solids becomes a central issue of the condensed matter physics. Time-reversal invariant topological insulator, a strong spin-orbit coupling system, make it possible to control the spin transport electrically. We demonstrate that electron tunneling through a p-n junction created electrically in HgTe quantum wells with inverted band structure exhibits interesting optic-like propagating behavior. We find a perfect intraband transmission for electrons injected perpendicularly to the interface of the p-n junction. A spin splitter can be realized using the Rashba spin-orbit interaction. The occurrence of a conductance plateau due to the formation of topological edge states in a quasi-one-dimensional p-n junction can be switched on and off by tuning the gate voltage.[1] A mechanical control, i.e., strain effect, can also creat a waveguide in a bulk graphene and leading a valley-polarized current utilizing the electron optics-like Goos-Hänchen effect.[2] We also demonstrate theoretically an electrical switching of the edge-state transport by means of a quantum point contact in a spin Hall bar. The switch-on/off of the edge channel is caused by the finite size effect of the quantum point contact and therefore can be manipulated by tuning the voltage applied on the split gate.[3] We propose to control the surface magnetism of three-dimensional topological insulators electrically. The helical Dirac electrons lead to the Heisenberg-like, Ising-like, and Dzyaloshinskii-Moriya (DM)-like spin-spin interactions, which can be tuned by changing the gate voltage. The gap opened by doped magnetic ions can lead to a short-range Bloembergen-Rowland interaction. The competition among the Heisenberg, Ising, and DM terms leads to rich spin configurations and an anomalous Hall effect on different lattices.[4]

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