Transport in topological insulators

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The quantum spin Hall (QSH) state, observed in two-dimensional topological insulators, respects the time-reversal symmetry and is characterized by gapless counterpropagating (helical) spin edge channels while the bulk states are fully gapped. Analogously, three-dimensional topological insulators are characterized by two-dimensional surface states. Naturally, magnetic field breaks the time reversal symmetry and allows for probing of nature of the edge channels and surface states.

In this talk we discuss theoretically magnetotransport properties of the helical edge channels and surface states.

In two-dimensional topological insulators in the quasiballistic regime, magnetic field does not mix the spin edge channels and QSH state persists in strong quantizing fields when the Fermi level lies in the gap [1]. With the shift of the Fermi level into the Landau-quantized conduction or valence band, we study a transition between the QSH and quantum Hall regimes. Near the transition the longitudinal conductance of the helical channels is strongly suppressed due to the combined effect of the spectrum nonlinearity and enhanced backscattering.

In three-dimensional topological insulators, the magnetic field dependence of galvanomagnetic and electromagnetic responses of the system shows anomalies due to broken time-reversal symmetry of the surface quantum Hall state, which can be used for its detection. In particular, we find [2] linear bulk dc magnetoresistivity and a quadratic field dependence of the Hall angle, shifted rf cyclotron resonance, nonanalytic microwave transmission coefficient and saturation of the Faraday rotation angle with increasing magnetic field or wave frequency.

[1] G. Tkachov and E. M. Hankiewicz *Phys. Rev. Lett*. **104**, 166803 (2010).
[2] G. Tkachov and E. M. Hankiewicz arXiv:1011.2756 (2010).