MAR16-2015-020429

Abstract for an Invited Paper
for the MAR16 Meeting of
the American Physical Society

Quantum Transport of Spin-helical Dirac Fermion Topological Surface States in Topological Insulators

YONG P. CHEN, Purdue University

Three-dimensional (3D) topological insulators (TI) are a novel class of electronic materials with topologically-nontrivial band structure such that the bulk is gapped and insulating yet the surface has topologically protected gapless conducting states. Such topological surface states (TSS) give helically spin polarized Dirac fermions, and offer a promising platform to realize various other novel physics such as topological magnetoelectric effects and Majorana fermions. However, it is often challenging to unambiguously access and study the transport properties of TSS in many practical TI materials due to non-negligible bulk conducting states. I will discuss our recent experiments on high-quality intrinsic TIs with insulating bulk and surface-dominated conduction that allow us to reveal a number of characteristic transport properties of spin-helical Dirac fermion topological surface states. We have observed, for example, a thickness-independent and surface-dominated conductance (even at room temperature) in exfoliated TI thin films [1] and well-developed half-integer Dirac fermion quantum Hall effect (QHE) arising from TSS (observed up to 40K) [1]; fully-tunable two-species Dirac fermion QHE and other intriguing states in dual gated devices where both top and bottom surfaces can be independently controlled [2]; current-induced helical spin-polarization detected by spin sensitive transport measurements using magnetic electrodes [3]; and in TI nanoribbons, Shubnikov-de Hass (SdH) oscillations showing gate-tunable Berry phase and ultra-relativistic Dirac mass [4]; and a half-integer Aharonov-Bohm effect (ABE) unique to the circumferentially quantized spin helical Dirac fermion surface state modes (sub-bands), with a gate-tunable conductance oscillation and alternation between the half-integer ABE and regular ABE periodic in fermi momentum [5]. Such TIs and related devices may enable promising future applications in spintronics, thermoelectrics and various topological quantum devices. References: [1] Y. Xu et al., Nature Physics 10, 956 (2014); [2] Y. Xu et al., arXiv:1511.04597 (2015); [3] J.Tian et al., Scientific Reports 5, 14293 (2015); [4] L. A. Jauregui et al., Scientific Reports 5, 8452 (2015); [5] L. A. Jauregui et al., Nature Nanotechnology, in press, arxiv:1503.00685 (2015).