Topological Insulators: Chapter 6. Topological Surface States: A New Type of 2D Electron Systems (Contemporary Concepts of Condensed Matter Science)

M. Zahid Hasan, Su-Yang Xu, David Hsieh, L. Andrew Wray, Yuqi Xia

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Topological Surface States (TSS) represent new types of two dimensional electron systems with novel and unprecedented properties distinct from any quantum Hall-like or spin-Hall effects. Their topological order can be realized at room temperatures without magnetic fields and they can be turned into magnets, exotic superconductors or Kondo insulators leading to worldwide interest and activity in the topic. We review the basic concepts defining such topological matter and the key experimental probe that revealed the topological order in the bulk of these spin-orbit interaction dominated insulators. This review focuses on the key results that demonstrated the fundamental topological properties such as spin-momentum locking, non-trivial Berrys phases, mirror Chern number, absence of backscattering, protection by time-reversal and other discrete (mirror) symmetries and their remarkable persistence up to the room temperature elaborating on results first discussed by M.Z. Hasan and C.L. Kane in the Rev. of Mod. Phys., 82, 3045 (2010). Additionally, key results on broken symmetry phases such as quantum magnetism and uperconductivity induced in topological materials are briefly discussed.

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