Topological Phases of Quantum Matter as Novel Platforms for Fundamental Science and Applications

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I will discuss how topological phases arise in quantum matter through spin-orbit coupling effects in the presence of protections provided by time-reversal, crystalline and particle-hole symmetries, and highlight our recent work aimed at predicting new classes of topological insulators (TIs), topological crystalline insulators, Weyl semimetals, and quantum spin Hall insulators. [1-10] Surfaces of three-dimensional (3D) topological materials and edges of two-dimensional (2D) topological materials support novel electronic states. For example, the surface of a 3D TI supports gapless or metallic states, which are robust against disorder and non-magnetic impurities, and in which the directions of momentum and spin are locked with each other. Similarly, in 2D TIs, also called quantum spin Hall insulators, the 1D topological edge states are not allowed to scatter since the only available backscattering channel is forbidden by constraints of time-reversal symmetry. The special symmetry protected electronic states in topological materials hold the exciting promise of providing revolutionary new platforms for exploring fundamental science questions, including novel spin textures and exotic superconductors, and for the realization of multifunctional topological devices for thermoelectric, spintronics, information processing and other applications. *Work supported by the U. S. Department of Energy.*

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