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Topological response in Weyl semimetals and metallic ferromagnets

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Standard picture of a topologically-nontrivial phase of matter is an insulator with a bulk energy gap, but metallic surface states, protected by the bulk gap. Recent work has shown, however, that certain gapless systems may also be topologically nontrivial, in a precise and experimentally observable way. In this talk I will review our work on a class of such systems, in which the nontrivial topological properties arise from the existence of nondegenerate point band-touching nodes (Weyl nodes) in their electronic structure. Weyl nodes generally exist in any three-dimensional material with a broken time-reversal or inversion symmetry. Their effect is particularly striking, however, when the nodes coincide with the Fermi energy and no other states at the Fermi energy exist. Such “Weyl semimetals” have vanishing bulk density of states, but have gapless metallic surface states with an open (unlike in a regular two-dimensional metal) Fermi surface (“Fermi arc”). I will discuss our proposal to realize Weyl semimetal state in a heterostructure, consisting of alternating layers of topological and ordinary insulator, doped with magnetic impurities. I will further show that, apart from Weyl semimetals, even such “ordinary” materials as common metallic ferromagnets, in fact also possess Weyl nodes in the electronic structure, leading to a non-quantized contribution to their intrinsic anomalous Hall conductivity, which can not be attributed to the Fermi surface.