Gapped and gapless topological phases in condensed matter systems

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Abstract

One of the defining properties of topological insulators and superconductors, which are topological phases with a full gap in the bulk, is the appearance of topologically protected zero-energy surface or edge states, some of which are of Majorana type. Boundary modes of topological nature can also occur in (semi-)metallic systems that exhibit topologically stable Fermi surfaces or in nodal superconductors with non-trivial topology. For instance, dispersionless boundary states exist on the (110) surface of a $d_{x^2-y^2}$-wave superconductor (e.g., in high-temperature superconductors), or at the zig-zag edge in graphene. In this talk I present a classification of both gapped and gapless topological phases in terms of symmetry and spatial dimension. As a consequence of the non-trivial bulk topology all of these systems exhibit topologically stable surface states, which are either dispersionless or show a linear dispersion as a function of edge or surface momentum. As a concrete example, superconductors without inversion symmetry are discussed in detail. Three different types of topologically protected surface states are identified in these systems, namely Kramers-degenerate Majorana modes, arc surface states, and surface flat bands, whose stability is guaranteed by the conservation of three different types of topological invariants. I examine the signatures of the Majorana modes, the arc surface states and the zero-energy surface flat bands in tunneling-conductance spectra and other experimental probes.