Topological matter: from Weyl fermions to room temperature superconductivity

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ABSTRACT

Topological media are gapped or gapless fermionic systems, whose properties are protected by topology. The class of gapless topological media contains in particular normal metals, chiral superfluids, graphene, cuprate superconductors, Weyl semimetals and quantum vacuum of Standard Model in its symmetric phase. These media have topologically protected zeroes in energy spectrum, such as Fermi surfaces (quantized vortices in **p**-space) and Weyl points (**p**-space monopoles). Vacua with Weyl points serve as a source of effective relativistic quantum field theories emerging at low energy: chiral fermions, effective gauge fields and gravity. The accompanying effects, such as chiral anomaly and its observed analogue in superfluid ^{3}He, are expressed via symmetry protected topological invariants. There are other exotic fermions: type-II Weyl fermions; Dirac fermions with quadratic, cubic, quartic ... touching of branches; nexus fermions; nodal line fermions; Majorana fermions living on the surface of the system or within the core of topological defects; flat band fermions; etc. All electrons within the flat band have exactly zero energy. This property crucially influences the critical temperature of the superconducting transition in media with flat band. While in all the known superconductors the transition temperature is exponentially suppressed as a function of the pairing interaction, in the flat band the transition temperature is proportional to the pairing interaction, and thus can be essentially higher. So topology gives us the general recipe for the search or artificial fabrication of the room-temperature superconductors.

References

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