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GAPLESS TOPOLOGICAL MATTER AND FLAT BANDS

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Abstract:

Topological media are systems whose properties are protected by topology, and thus are robust to deformations and generic. Examples are topological superconductors, topological insulators, topological semimetals, graphene, superfluid phases of 3He, and even quantum vacuum of Standard Model of elementary particles. These systems may exhibit quantization of physical parameters, such as quantized spin Hall conductivity, and have exotic excitations living on the edge of a topological systems, such as Majorana fermions. We concentrate on the topological semimetals - substances intermediate between insulators and metals. Instead of the metallic Fermi surface they have the Dirac points or Dirac lines - topologically protected point nodes or nodal lines in the spectrum of electrons. An example of semimetals with point nodes is the vacuum of Standard model, while an example of semimetals with nodal lines is a metastable form of graphite with a rhombohedral stacking of graphene layers. The unique property of a semimetal with nodal lines in bulk is that its surface contains electrons without dispersion: all electrons within such a flat band on the surface have exactly zero energy. This property crucially influences the critical temperature of the superconducting transition. 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. Search for or artificial fabrication of such semimetals may thus open the route to room-temperature superconductivity.