PT-invariant Weyl semimetals

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Weyl semimetals typically appear in systems in which either time-reversal (T) or inversion (P) symmetry is broken. Here we show that these are not the only possibilities: in the presence of gauge potentials this topological state of matter can also arise in fermionic lattices preserving both T and P. The paradigmatic case is a cubic lattice model with π-fluxes, a model which is invariant under a physical PT transformation and is realizable with ultracold fermions trapped in optical lattices. In this system, gauge symmetries play a fundamental role in the formation of Weyl points, and it is necessary to introduce a distinction between canonical and physical T and P symmetries. This PT invariant Weyl phase is stable against the main perturbations which may characterize its ultracold atom realizations, as, for example, the introduction of a trapping potential. Also the presence of random perturbations of the (artificial) magnetic fluxes do not destroy this phase for finite size systems under realistic assumptions and can be compared to a local disorder in solid state scenarios. Finally, the construction of PT-invariant Weyl semimetal can be extended to systems with a U(2) gauge potentials, thus including both magnetic fluxes and a spin-orbit coupling. When the non-Abelian potential is turned on, due to the presence of a C_4 rotation symmetry, the Weyl points assume a quadratic dispersion along two directions and constitute double monopoles for the Berry curvature.

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