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Study of Linear Response in Rarita-Schwinger-Weyl Semimetals

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Abstract

Rarita–Schwinger–Weyl (RSW) semimetals are an emergent class of topological quantum materials where low-energy quasiparticles behave as spin-3/2 fermions rather than the conventional spin-1/2 Dirac or Weyl fermions. These excitations are described by the Rarita–Schwinger equation, originally formulated in high-energy physics to describe particles of spin 3/2, but realized in condensed matter as band crossings with four-component pseudospin degrees of freedom. Studying linear response functions in these systems is essential for understanding how these unconventional quasiparticles interact with external perturbations such as electromagnetic fields, thermal gradients, and strain. Linear response theory connects microscopic Hamiltonians to observable physical quantities like conductivity, optical absorption spectra, and collective modes. Although Weyl semimetals exhibit the chiral anomaly — leading to negative magnetoresistance under parallel electric and magnetic fields — the situation in RSW semimetals is more subtle. The anomaly coefficient can be enhanced or suppressed depending on the topological charge and orbital character of the degeneracy point. The study of linear response in Rarita–Schwinger–Weyl semimetals is a rich field at the intersection of topological band theory, many-body physics, and materials science. The spin-3/2 character of quasiparticles gives rise to novel transport and optical signatures that differ qualitatively from conventional Weyl and Dirac systems. Linear response theory provides the essential framework for connecting microscopic Hamiltonians with measurable physical quantities, offering pathways to discover and characterize new quantum materials with exotic excitations.

Keywords: Linear, Response, Rarita-Schwinger-Weyl, Semimetals