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Quantum Kinetic Theory of Magnetotransport in Weyl Metals

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The Weyl semimetal has attracted much attention as a topological phase of matter. Its topological nature is experimentally manifested by the existence of chiral anomalies, and in particular by a negative magnetoresistance (or equivalently a positive quadratic magnetoconductance) for parallel electric and magnetic fields. Although several theoretical studies have derived expressions for the chiral-anomaly-induced magnetoconductance, the conditions required for its appearance have not yet been fully understood. In this talk, we present a general theory of low-field magnetotransport based on a quantum kinetic equation. Our theory naturally includes the Berry phase effects that arise from topologically nontrivial band structures and are often discussed in terms of semiclassical wavepacket dynamics, and properly accounts for their subtle interplay with electron scattering effects. Using our theory, we attempt to understand from the quantum kinetic theory viewpoint when the chiral anomaly emerges in condensed matter systems. As an illustration, we derive an explicit expression for the quadratic magnetoconductance implied by a simple microscopic model of Weyl semimetals, demonstrating explicitly that the chiral anomaly emerges only when intervalley scattering is sufficiently weak.

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