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Effective Field Theory of Clean Interacting Semimetals[1] G.J. DE COSTER, Department of Physics, University of Oregon, D. BELITZ, Department of Physics and Institute of Theoretical Science, University of Oregon, T.R. KIRKPATRICK, Institute for Physical Science and Technology, University of Maryland
— We present an effective field theory for interacting electrons in clean semimetals (both Weyl semimetals and graphene) in terms of their soft or massless degrees of freedom. We show, by means of a Ward identity, that the intrinsic semimetal groundstate breaks an Sp(N) symmetry of the theory. In Fermi liquids this enables one to identify the massive, non-Goldstone modes of the theory and integrate them out. Due to the vanishing density of states in semimetals, unlike in Fermi liquids, both Goldstone and non-Goldstone modes are equally soft, and so all two-particle correlations need to be kept. The resulting theory is not perturbative with respect to the electron-electron interaction; rather,it is controlled by means of a systematic loop expansion and allows for a renormalization-group analysis in a natural way. As a representative application, we use the theory to compute the zero-bias anomaly for the density of states for both short and long-range interactions in $d = 2, 3$. We find that the leading nonanalyticity in semimetals with a long-ranged interaction is identical to the one in Fermi liquids, since the effects of the vanishing density of states at the Fermi level are offset by the breakdown of screening.

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