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Effects of incipient pairing on nonequilibrium quasiparticle transport in Fermi liquids.
(English) [Zbl 07543133]
PTEP, Prog. Theor. Exper. Phys. 2022, No. 3, Article ID 033I02, 26 p. (2022)

Summary: The low-temperature properties of a wide range of many-fermion systems spanning metals, quantum gases and liquids to nuclear matter are well understood within the framework of Landau’s theory of Fermi liquids. The low-energy physics of these systems is governed by interacting fermionic quasiparticles with momenta and energies near a Fermi surface in momentum space. Nonequilibrium properties are described by a kinetic equation for the distribution function for quasiparticles proposed by Landau. Quasiparticle interactions with other quasiparticles, phonons, or impurities lead to internal forces acting on a distribution of nonequilibrium quasiparticles, as well as collision processes that ultimately limit the transport of mass, heat, charge, and magnetization, as well as limiting the coherence times of quasiparticles. For Fermi liquids that are close to a second-order phase transition, e.g., Fermi liquids that undergo a superfluid transition, incipient Cooper pairs – long-lived fluctuations of the ordered phase – provide a new channel for scattering quasiparticles, as well as corrections to internal forces acting on the distribution of nonequilibrium quasiparticles. We develop the theory of quasiparticle transport for Fermi liquids in the vicinity of a BCS-type superfluid transition starting from Keldysh’s field theory for nonequilibrium, strongly interacting fermions. The leading corrections to Fermi-liquid theory for nonequilibrium quasiparticle transport near a Cooper instability arise from the virtual emission and absorption of incipient Cooper pairs. Our theory is applicable to quasiparticle transport in superconductors, nuclear matter, and the low-temperature phases of liquid $^3$He. As an implementation of the theory we calculate the pairing-fluctuation corrections to the attenuation of zero sound in liquid $^3$He near the superfluid transition and demonstrate quantitative agreement with experimental results.

MSC:

- 82-XX Statistical mechanics, structure of matter
- 81-XX Quantum theory

Full Text: DOI arXiv