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EINLADUNG zum IFP-SEMINAR

Landau's Fermi Liquids with Hidden Quasiparticles

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Abstract:

Landau's Fermi liquids, paradigm of interacting electrons, are characterized by the existence of single-particle excitations, the 'quasiparticles', with well-defined energy dispersion in momentum space and whose lifetime grows to infinity approaching the quasiparticle 'Fermi surface', i.e., the location in the Brillouin zone of the zeros of the quasiparticle energy measured with respect to the chemical potential. Those quasiparticles fully determine the long-wavelength, low-energy, and low-temperature behavior of the interacting system.

The traditional microscopic derivation of Landau's Fermi liquid theory relies on the validity of perturbation theory. In that case, quasiparticles appear as peaks in the spectral function that grow and narrow approaching the quasiparticle 'Fermi surface', rigorously defined through the poles in momentum space of the single-particle Green's function at zero energy and temperature.

Therefore, each time quasiparticle peaks are absent in the spectral function, that lack is attributed to a breakdown of Landau's Fermi liquid theory, and often happens in strongly-correlated materials, most notably, in the pseudo-gap phase of underdoped cuprates.

However, many purported non-Fermi liquids missing quasiparticle peaks have physical properties that instead hint at the existence of quasiparticles. The most striking example are quantum oscillations, another fingerprint of quasiparticles, and finite specific heat coefficients in the Kondo insulators SmB_6 and YbB_{12}.

Here, we show that this Janus-faced behavior can be perfectly reconciled with Landau's Fermi liquid theory. Specifically, we demonstrate that Landau's Fermi liquid theory can be microscopically derived even when the single-particle Green's function at zero energy and temperature has a surface of zeros, the so-called Luttinger surface breaking perturbation theory, instead of the Fermi surface poles. Quasiparticles at the Luttinger surface, invisible in the spectral function, are incompressible, do not contribute to the Drude weight, and yet they yield linear in temperature specific heat and thermal conductivity, Pauli-like magnetic susceptibility and, possibly, quantum oscillations. Therefore, for instance, a Mott insulator with a Luttinger surface realizes a spin-liquid insulator, with the Luttinger surface playing the role of the 'spinon' Fermi surface.