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Non-Fermi-liquid dynamics of the two-channel Kondo lattice

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Abstract

The paramagnetic phase of the two-channel Kondo lattice model is examined with a quantum Monte Carlo simulation in the limit of infinite dimensions. We find non-Fermi-liquid behavior at low temperatures including a finite low-temperature single-particle scattering rate, no Fermi distribution discontinuity, and zero Drude weight. Both the optical and quasiparticle mass enhancement and scattering relaxation rate show consistent evidence of non-fermi-liquid behavior. However, the low-energy density of electronic states is finite.

Keywords: Non-Fermi liquid system; Dynamics

1. Introduction

The Fermi-liquid theory of Landau has provided a remarkably robust paradigm for describing the properties of interacting Fermion systems such as liquid ^{3}He and alkali metals (e.g., sodium). The key notion of this theory is that the low-lying excitations of the interacting system possess a 1 : 1 map to those of the noninteracting system and hence are called "quasiparticles". In the metallic context, one may think of the quasiparticles as propagating electron-like wave packets with renormalized magnetic moment and effective mass reflecting the "molecular field" of the surrounding medium. A sharp Fermi surface remains in the electron occupancy function n_k which measures the number of electrons with a given momentum, and for energies ω and temperatures T asymptotically close to the Fermi surface the excitations have a decay rate going as $\omega^2 + \pi^2(k_B T)^2$, which is much smaller than the quasiparticle energy. This generally translates into a T^2 contribution to the electrical resistivity $\rho(T)$ and an ω^2 contribution to the scattering relaxation rate $\Gamma(\omega)$ inferred from the optical conductivity, and both the optical and single-particle electronic masses are found to be enhanced but positive and finite.

The Fermi-liquid paradigm appears now to be breaking down empirically in numerous materials, notably a number of fully three-dimensional heavy-Fermion alloys and compounds [1]. In these systems anomalies such as conductivity with linear dependence on ω, T and logarithmically divergent linear specific heat coefficients are often observed. In addition, in some heavy-fermion lattice compounds, such as UBe_{13} [2] and $CeCu_2Si_2$ [3], the superconductivity arises in a normal state which is clearly *not* described as a Fermi-liquid. Specifically, the resistivity is approximately linear in T above the transition, and the magnitude of the resistivity at the transition is high (typically 80–100 $\mu\Omega$ cm in UBe_{13} even in the best samples). If the quasiparticle paradigm indeed breaks down, this may require completely new concepts to explain the superconducting phases of these materials. While the Luttinger liquid theory provides an elegant way to achieve non-Fermi-liquid theory in

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