Non-Fermi liquid behavior in heavy electron system due to nested Fermi surface

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Landau's Fermi liquid theory has been successful in describing the low energy properties of most normal metals. Numerous U, Ce and Yb based heavy fermion systems display deviations from Fermi liquid behavior, known as non-Fermi liquid behavior, which can be tuned by alloying (chemical pressure), hydrostatic pressure or the magnetic field. In most cases the systems are close to the onset of antiferromagnetism and the non-Fermi liquid behavior is attributed to a quantum critical point (QCP).

A nested Fermi surface together with the remaining interaction between the carriers after the heavy particles are formed may give rise to itinerant antiferromagnetism. The model under consideration consists an electron pocket and a hole pocket, separated by a wave vector $\mathbf{Q}$, and Fermi momenta k_{F1} and k_{F2}, respectively. The order can gradually be suppressed by increasing the mismatch of the Fermi momenta, defined as $2\delta = v_F|k_{F1} - k_{F2}|$, and a quantum critical point is obtained as $T_N \to 0$.

The mismatch of the Fermi vectors, δ, has the following consequences: (i) The specific heat over T and the magnetic susceptibility increase with the logarithm of the temperature as T is lowered.[1] (ii) For the tuned QCP the linewidth of the quasi-particles is sublinear in T and ω.[2] (iii) The specific heat and the linewidth display a crossover from non-Fermi liquid ($\sim T$) to Fermi liquid ($\sim T^2$) behavior with increasing nesting mismatch and decreasing temperature.[2] (iv) The dynamical conductivity displays deviations from the normal Drude behavior. (v) For small $\mathbf{q}$, the dynamical spin-susceptibility, $\chi''(\omega, \mathbf{Q}+\mathbf{q})$, (relevant for neutron scattering) has a peak at $\omega \approx \pm 2\delta$. The height and width of the peak are a function of T and δ. For smaller ω the response has a pseudo-gap. (vi) With increasing $\mathbf{q}$ the gap in $\chi''(\omega, \mathbf{Q}+\mathbf{q})$ is gradually closed and for $v_F q > 2\delta$ a quasi-elastic peak develops. (vii) While the specific heat, homogeneous susceptibility and the quasi-particle linewidth are only weakly dependent on the geometry of the nested Fermi surfaces, the momentum-dependent dynamical susceptibility is strongly affected by the shape of the Fermi surface.

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[1] P. Schlottmann, Phys. Rev. B **68**, 125105 (2003).
[2] P. Schlottmann, Phys. Rev. B **73**, 085110 (2006).