Low-Temperature Transport Properties of UPt$_3$ and TiBe$_2$ and Single-Component Fermi Liquid Theory

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(Received February 6, 1987)

A single-component Fermi liquid model is used to estimate the quasiparticle-quasiparticle scattering contribution to the transport properties of the heavy-electron systems UPt$_3$ and TiBe$_2$. The scattering amplitudes are obtained from an analysis of the low-temperature behavior of the specific heat. The calculated transport coefficients are in good agreement with measurements on UPt$_3$; the electrical resistivity of TiBe$_2$ lies an order of magnitude below the calculation.

At sufficiently low temperature, Landau's Fermi liquid theory provides the appropriate language for describing the normal state properties of any system of interacting fermions. Indeed, Pethick et al.\(^1\) (hereafter PZQB\(^2\)) have used Landau Fermi liquid theory and a simplified model of the Fermi surface to explain the appearance of a $T^3 \ln T$ term in the specific heat of the heavy-electron system UPt$_3$. They extract the spin-fluctuation Landau parameter $F_0^s$ and use it to obtain the pressure dependence of the superconducting transition temperature. Here we show that for a range of values of the effective mass parameter $F_0^t$ it is possible to use the PZQB\(^2\) value of $F_0^s$ to construct quasiparticle-quasiparticle (qp-qp) scattering amplitudes that describe the low-temperature electrical resistivity, thermal resistivity, and ultrasonic attenuation observed in UPt$_3$. We also present a similar analysis for TiBe$_2$.

There is strong evidence for qp-qp scattering contributions to the low-temperature transport properties of UPt$_3$. The electrical resistivity data of Willis et al.\(^2\), reproduced in Fig. 1, and of Ponchet et al. display a $T^2$ behavior along with the usual temperature-independent impurity scattering contribution from $T_c$ to about 1.5 K. The $T^2$ coefficient $\rho_{ee}$ for current along the hexagonal c axis is $0.54 \mu \Omega \cdot \text{cm} / \text{K}^2$ in magnitude—some six orders of magnitude greater than that observed in ordinary metals. Moreover, $\rho_{ee}$ is sample-independent, which is evidence that it is an intrinsic property of UPt$_3$ and not the result of imperfections and defects. The thermal resistivity...
We now ask whether the magnitude of these $T^2$ contributions to the transport properties of the normal state can be understood in terms of the scattering amplitudes obtained from specific heat measurements. Following $P^2QB^2$, we model the heavy electrons as a system of pseudo-spin-1/2 quasiparticles in the neighborhood of a spherical Fermi surface. We further