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Terahertz-frequency test for Fermi liquid conductivity in MnSi

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Fermi liquid theory predicts that electron-electron scattering will contribute $\rho_{e-e}(\omega, T) = A\left[(\hbar\omega)^2 + b(\pi k_B T)^2\right]$ to the frequency-dependent resistivity of any metal at low temperatures and frequencies. In its simplest form, the theory further predicts that the temperature and frequency dependence are related by $b = 4$, but numerous experimental studies have yielded $b \approx 1$ for different metals, and none have observed the predicted value. I will review progress in understanding this issue, with an emphasis on our measurements on MnSi with terahertz time-domain spectroscopy. As with other metals, the resistivity exhibits the quadratic frequency dependence predicted by Fermi liquid theory, but with $b \approx 1$ over a wide range in temperature. At the lowest temperatures, we observe evidence for a crossover to $b \approx 4$, although this is currently limited by a large systematic uncertainty that we will discuss. Additionally, we have determined the Drude scattering rate and plasma frequency at low temperatures, and compared these to realistic band theory calculations. Above a coherence temperature $T_{coh} \approx 50$ K, we find evidence for the existence of a pseudogap. Below T_{coh}, τ increases dramatically to $\tau \approx 0.5$˜ps at $T \approx 5$˜K. From a comparison of the low-temperature plasma frequency measurement with band theory, we determine a mass renormalization of $m^*/m \approx 5.5$, which compares favorably with earlier quantum oscillation measurements.

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