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Thermal Transport Beyond the Mott-Ioffe-Regel Limit

The Boltzmann-Drude picture of electronic transport ceases to be valid when the electron mean-free-path becomes shorter than the Fermi wavelength. The Mott-Ioffe-Regel limit is defined where the two lengths are equal, and beyond it metallic transport becomes incoherent. Most experimental works have focused on the electronic transport, with the host crystal providing a phonon background. Here we report thermal diffusivity measurements that, together with the resistivity, give a full account of transport of charge and entropy. Utilizing a high-resolution photothermal apparatus, we study the thermal diffusivity of several cuprate systems in the regime where the quasiparticle picture fails for both electron and phonons. The inverse diffusivity at high temperature can be fitted with a temperature-linear form, where the slope term is set by a unique velocity and a Planckian relaxation time $\sim \hbar/kBT$, The constant term represents a quantum-diffusion constant separating incoherent transport from a regime with well-defined quasiparticles.