Kohler's Rule and Planar Resistivity in the Cuprate Superconductor $HgBa_2CuO_{4+\delta}$

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Introduction

We report in-plane resistivity and transverse magnetoresistance (MR) measurements in underdoped $HgBa_2CuO_{4+\delta}$ (Hg1201; T_c=71K, hole doping p~0.095, sample labeled HgUD71). Contrary to the longstanding view that Kohler's rule is strongly violated in underdoped cuprates, we found that it is in fact satisfied in the pseudogap phase of Hg1201. The transverse MR shows a quadratic field dependence, $\delta\rho/\rho_0 = aH^2$, with $a(T) \propto T^{-4}$. In combination with the observed $\rho \propto T^2$ dependence, this is consistent with a single Fermi-liquid quasiparticle scattering rate.

Experimental

Measurements were carried out in magnetic DC fields (up to 35T) at various temperatures.

Results and Discussion

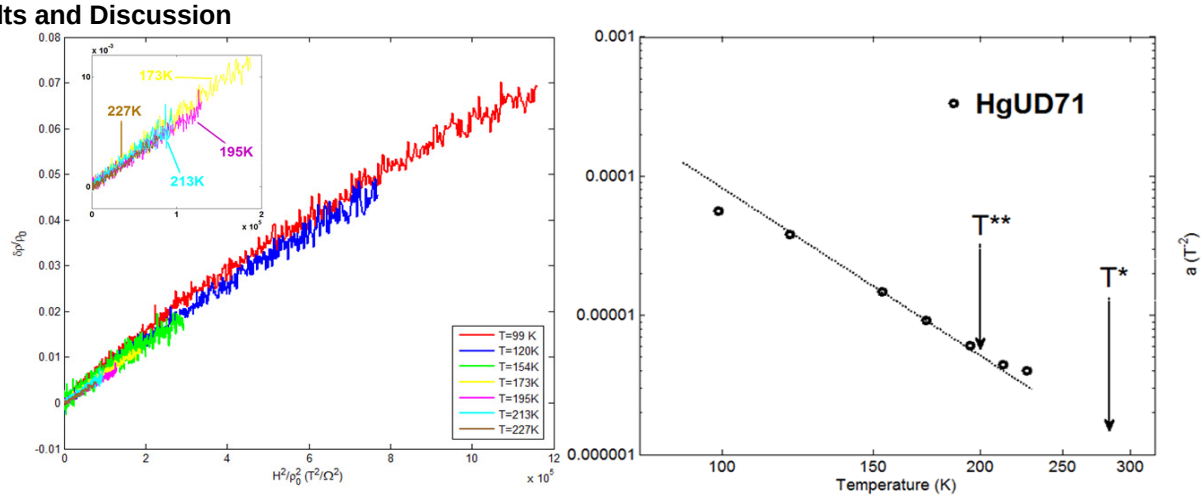

Figure 1.Magnetoresistance of HgUD71. Left: Kohler plot , with maximum static field of 35 T.ρ_0 is extrapolated from fits of the resistivity (ρ) versus field (H) data to $\rho = \rho_0 + bH^2$. Right: Log-log plot of the temperature dependence of the transverse MR coefficient. The line is a fit to $a = a_0 T^{-4}$. Arrows indicate the PG temperature T* and Fermi-liquid behavior characteristic temperature T**.

Fig.1 shows Kohler's plot of $\delta\rho/\rho_0$ versus $(H/\rho_0)^2$. The fact that the data collapse to a single curve means that Kohler's rule is satisfied [1, 2]. This is only possible if the temperature dependence of the scattering rate does not have a significant dependence on the location along the Fermi surface. This condition is satisfied most naturally if there is only a single temperature-dependent scattering rate. For a Fermi liquid with $1/\tau \propto T^2$, Kohler's plot implies $\delta\rho/\rho_0 \propto H^2 T^{-4}$. This is demonstrated in Fig. 1b. Other independent zero-field charge and optical transport experiments on Hg1201 revealed Fermi-liquid behavior as well [3, 4].

Conclusions

We conclude that Kohler's rule is satisfied in underdoped Hg1201 and that the transverse magneto-resistance (MR) shows a quadratic field dependence, $\delta\rho/\rho_0 = aH^2$, with $\propto T^{-4}$ [2]. In combination with the observed $\rho \propto T^2$ dependence, this is consistent with a single Fermi-liquid quasi-particle scattering rate.

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