# Hidden universal mobility in LSCO unveiled by Ni impurity

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In cuprates, the inverse of Hall mobility, $\mu^{-1}$ ($\mu = |R_H|/\rho_{xx}$), is known to exhibit a quadratic temperature dependence, with the proportionality coefficient $C_{univ}$ found to be universal across four cuprate families [1]. The investigated x=0.15 LSCO composition (LSCO15) falls within the range x>0.08, which is an exception to this universality and can be ascribed to the Lifshitz transition [1]. The $C_2$ coefficient in $\cot\theta_H(T)$=$C_0$+$C_2T^z$ ($z$=2) dependence forms here a systematic trend $C_2(x)$ which significantly deviates from $C_{univ}$. To reconcile, a substantial adjustment of the experimental data has been proposed [1], [2]. We will show that no such correction is required when transport in LSCO is probed by Ni doping and analyzed within the framework of Hussey's anisotropic scattering rate saturation (ASRS) model [3].

We present Hall effect measurements on LSCO15 with Ni impurity (LSCNO) and compare them with our other transport data. The exponent $z$ deviates from 2 in the parent LSCO15, sharpens to a quadratic dependence at $y$=0.035, and then softens to $z$=1.84 at $y$=0.07. The Hall coefficient $R_H(T)$ shows nonmonotonic behavior, decreasing after an initial increase above $y$=0.035, while the Seebeck coefficient $S(T)$ indicates a linear reduction in mobile carrier concentration $n$ up to $y$=0.09. The pseudogap temperature line $T^*(y)$ in LSCNO—determined from zero-field resistivity, longitudinal magnetoresistance, Hall effect, and thermopower— matches that of LSCO with $x$=$n$=$0.15-y$ scaling, reflecting a Ni-induced carrier localization rate of one hole per Ni ion, with the extrapolated $T^*$=0K concentration $n_{cr}$=0.26±0.01 positioned at the end of the superconducting dome in the phase diagram.

We demonstrate that transport below the quasiparticle decoherence temperature ($\sim$360 K for LSCO15) can be modeled within conventional Boltzmann theory using a modified ASRS model, which stems from the parallel-resistor formalism and is based on an anisotropic scattering rate $\Gamma$. For LSCNO, incorporating distinct maximal shunting rates—which must be rigorously evaluated in the nodal and antinodal regions—is essential. These originate from differing Ioffe-Regel-Mott limits and Fermi velocities for the two relevant directions. The model, adapted to LSCNO, is capable of reproducing the effective $\Gamma$ and thus reconstructing the transverse resistivity $\rho_{xy}(T)$ using a single parameter set from the parallel-resistor model describing the longitudinal resistivity $\rho_{xx}(T)$ and reasonable anisotropy factors. As a consequence, the experimental $\cot\Theta_H(T) = \rho_{xx}/\rho_{xy}(T)$ is reproduced very well, including the softening exponent $z$ from the approximate dependence above. The extrapolated fit parameters reveal an *isotropic* quadratic temperature dependence of $\mu^{-1}$ near optimal doping in LSCO, with the proportionality coefficient equal to $C_{univ}$.

## References

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