Transport properties in the strange metal phase of cuprates: a hydrodynamical description

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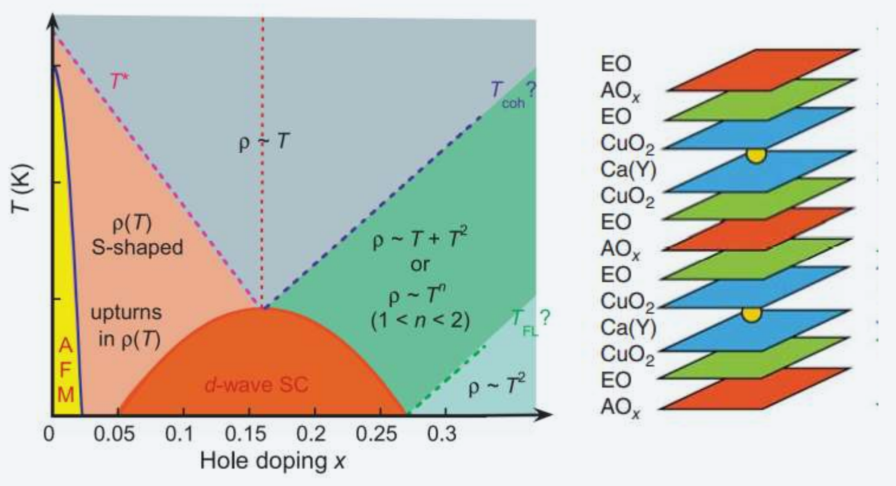
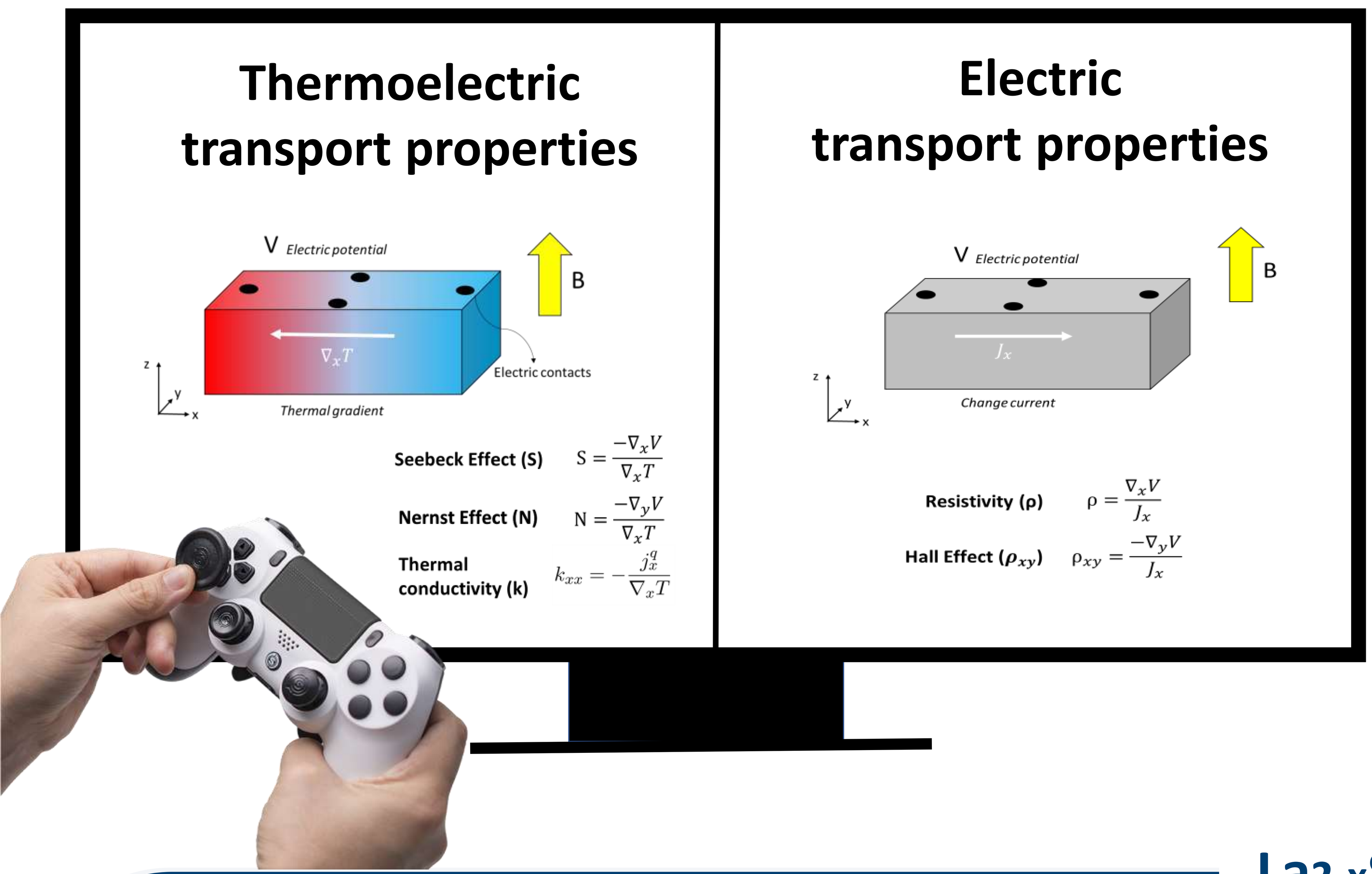
Cuprates

High-Tc cuprate superconductors (HTS) are strongly coupled systems presenting a surprising phase diagram with many intertwined phases appearing at the same time [1].
Moreover, in the normal state, the transport properties present anomalous behaviours and cannot be explained with the Fermi liquid theory [2]. These anomalies seems to be ascribed to the presence of a Quantum Critical Point (QCP), hidden inside the SC dome at T=0 [3].





Hydrodynamical approach

Hydrodynamics is a tool which gives an accurate description of any interacting system, classical or quantum. In normal Fermi-liquid systems, however, the quasiparticles interact with each other very weakly, making the observation of the hydrodynamics of electron fluids really hard. Instead, in systems such as cuprates, the strong interactions between electrons make the quasiparticle Fermi-liquid picture unreliable, and hydrodynamics is the ideal framework to describe the relaxation of these modes.

Within the hydrodynamical scenario, we analyzed how the hydrodynamical approach constrains the entire set of electric, thermo-electric, and thermal DC transport coefficients.
The low-B behavior of the DC electric resistivity ρ_{xx}, the Hall angle $\cot\Theta_H=\sigma_{xx}/\sigma_{xy}$, the magnetoresistance $\Delta\rho/\rho$, the Nernst coefficient N, and the thermal Hall conductivity κ_{xy} are presented.

σ_0 and $\tilde{\sigma}$ are the incoherent and relaxation conductivities, T is the temperature, and s and n are the entropy density and the charge-carrier density, respectively.
The parameter α_0 is an incoherent thermo-electric conductivity.
The expressions have been obtained supposing that near the QCP $\sigma_Q >> \sigma_D$.

$$\rho_{xx} \sim \frac{1}{\sigma_0}$$

$$\frac{\Delta\rho}{\rho} \sim \frac{\tilde{\sigma}}{n^2}\sigma_0$$

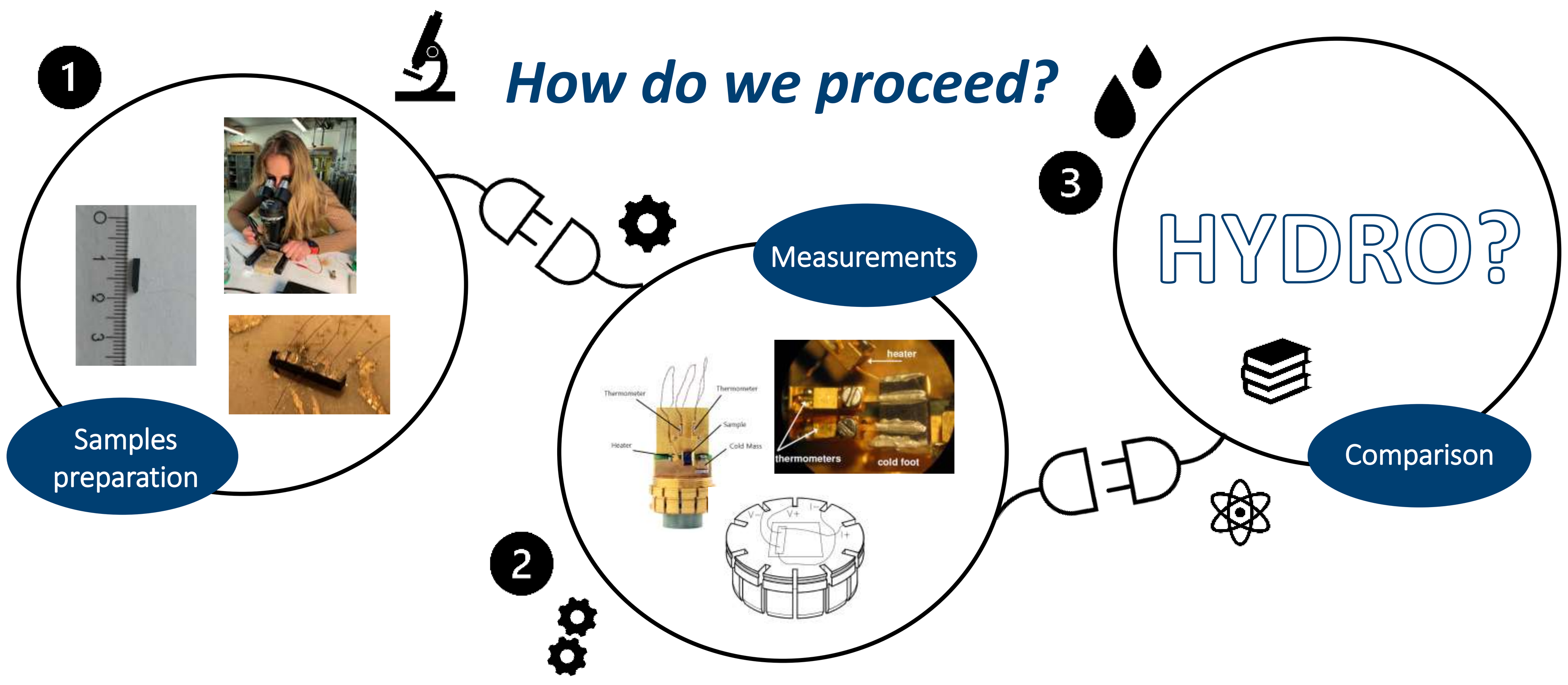
$$\cot\Theta_H \sim \frac{n}{B\tilde{\sigma}}$$

$$\kappa_{xy} \sim \mu B\frac{\sigma_0\tilde{\sigma}}{n^2}s$$

$$N \sim \mu B\frac{\tilde{\sigma}}{n\,T}$$

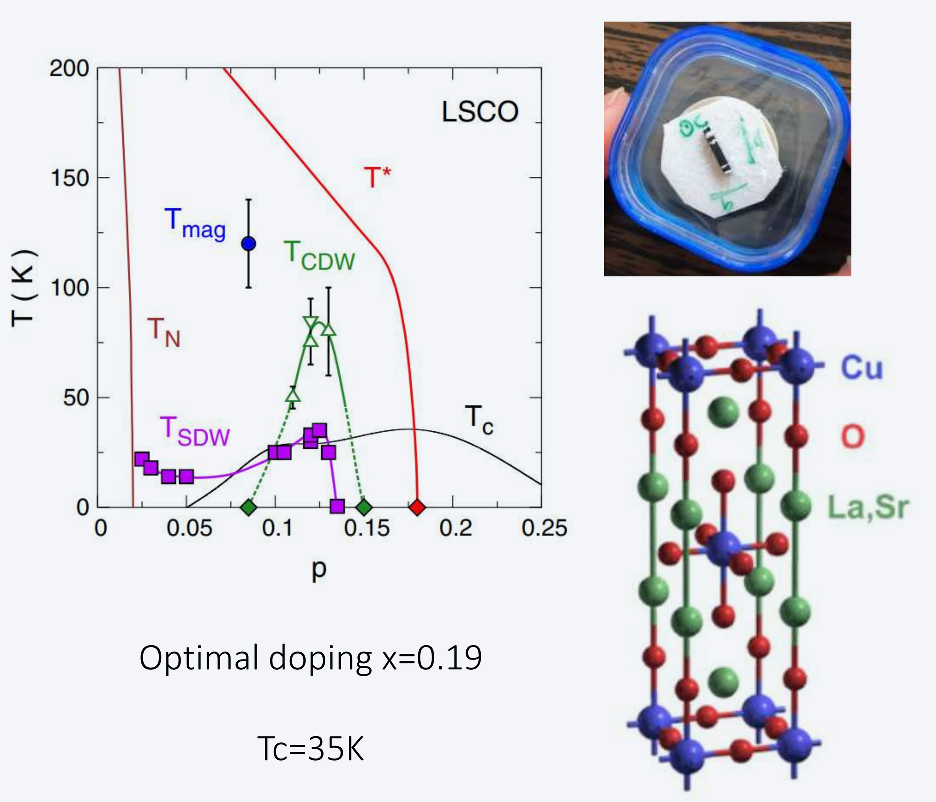
$$\frac{S}{T} \sim \frac{s\tilde{\sigma}}{n}$$

How do we proceed?



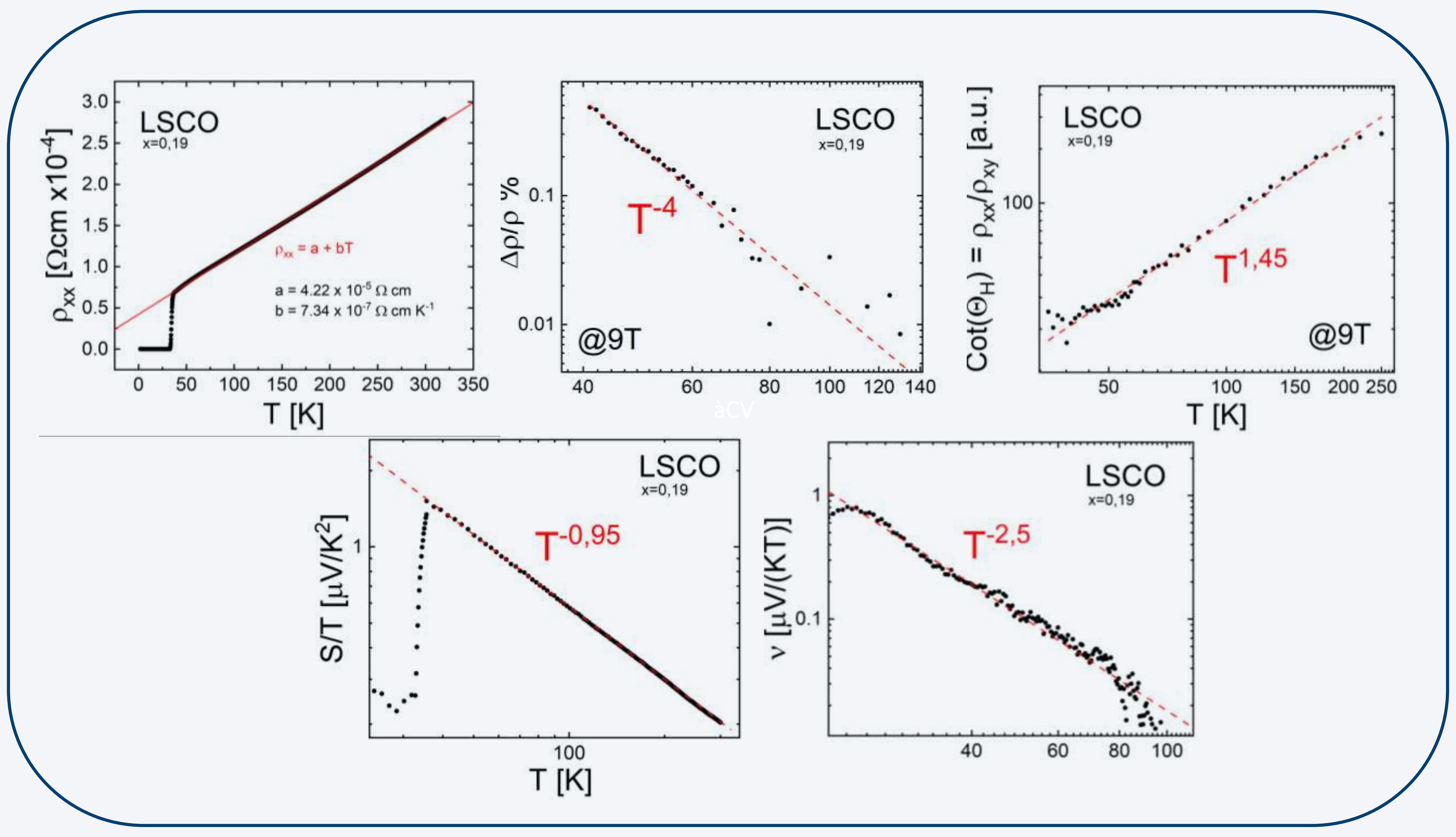
La2-xSrxCuO4

La1.81Sr0.19CuO4



Optimal doping x=0.19

Tc=35K

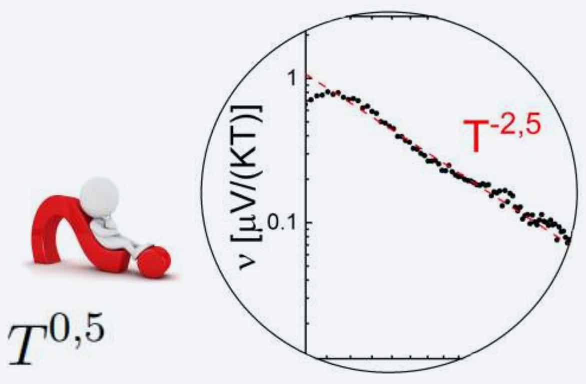


Hydrodynamical parameters

$\sigma_0 \sim T^{-1}$
$\tilde{\sigma} \sim T^{0.1}$
$n \sim T^{1.5}$
$s \sim T^{0.5}$

Hydrodynamical prediction

$\nu \propto T^{-2,5}$

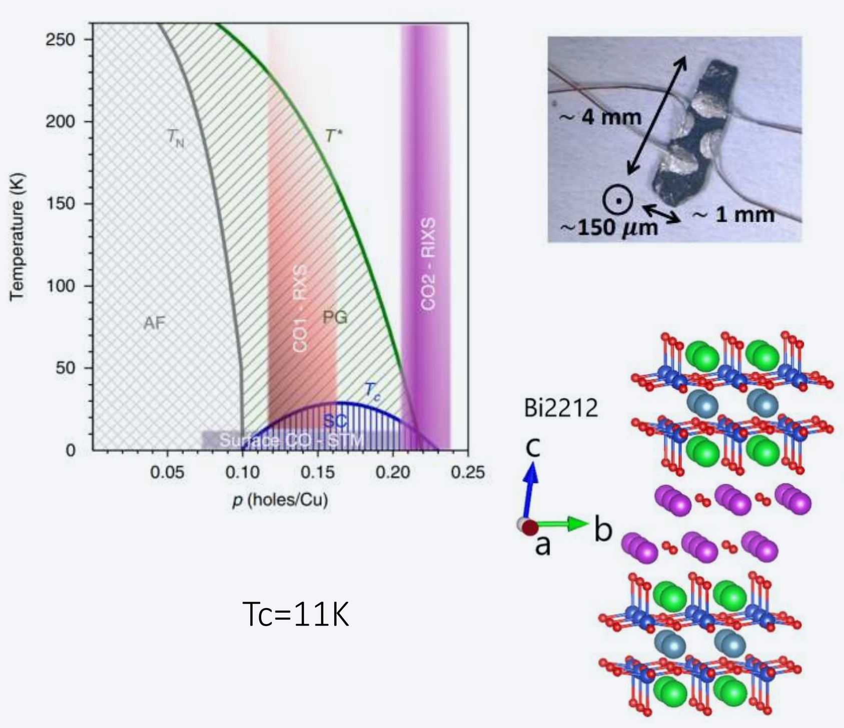


$\oplus\ s \propto T^{0,5}$

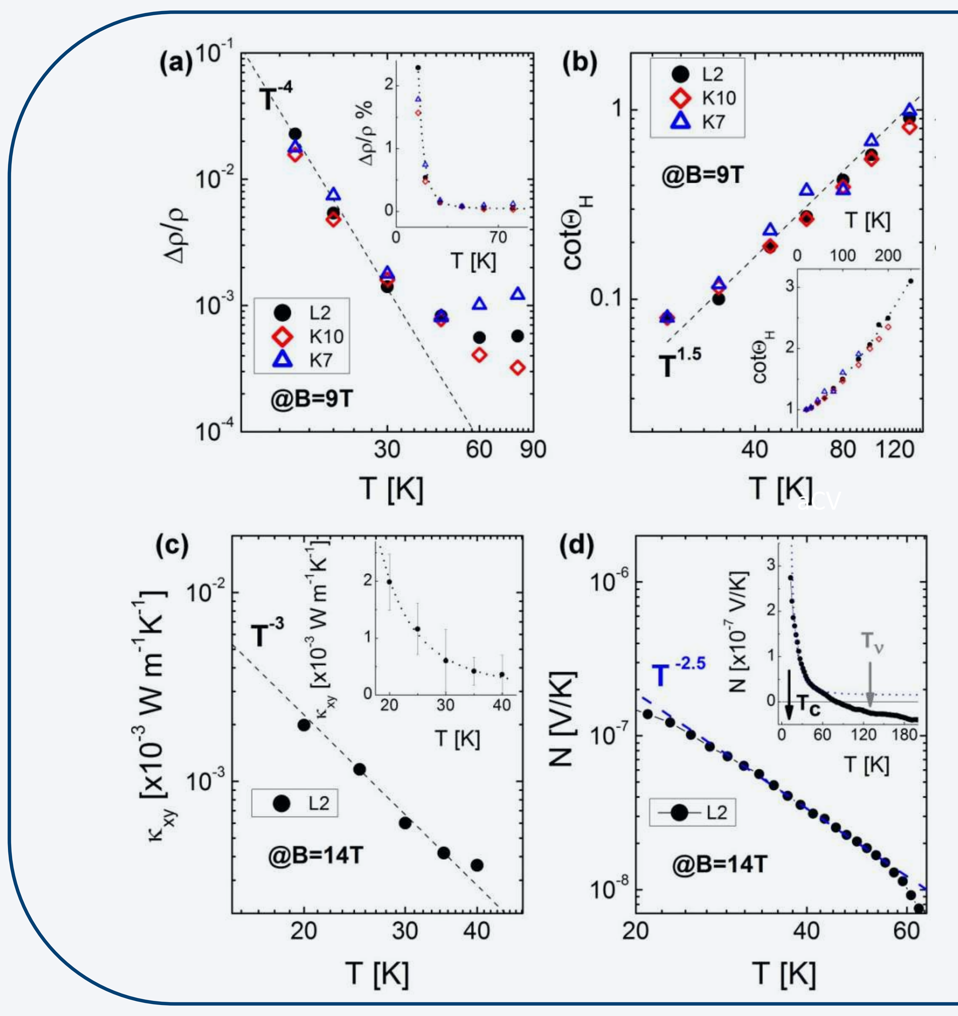
The work on LSCO is still ongoing.
Transverse thermal conductivity measurement will be performed soon in order to clarify this mismatch.

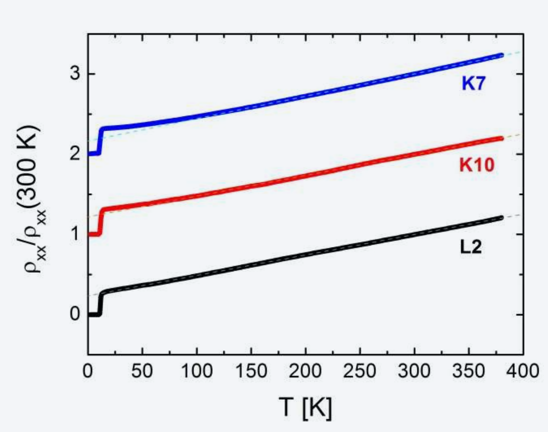
Bi2Sr2CuO6+x

Bi2Sr2CuO6.04 [5]



Tc=11K



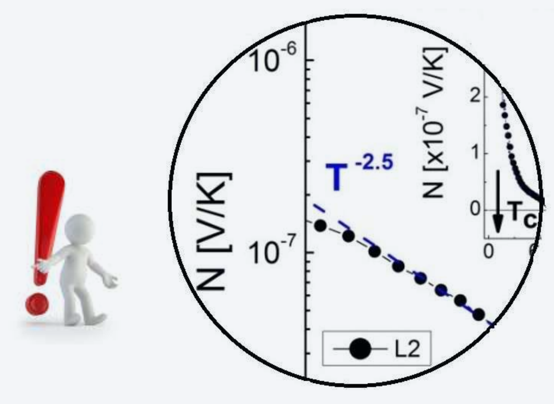


Hydrodynamical parameters

$\sigma_0 \sim T^{-1}$
$\tilde{\sigma} \sim T^{0}$
$n \sim T^{1.5}$
$s \sim T$

Hydrodynamical prediction

$$N \sim \frac{\mu B\tilde{\sigma}}{nT}$$



References

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