

Supplementary Information for

**Percolative nature of the direct-current paraconductivity in cuprate
superconductors**

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Supplementary Text

Fermi-liquid normal-state of Hg1201. Figure S1 shows the planar resistivity of $\text{HgBa}_2\text{CuO}_{4+\delta}$ (Hg1201; $T_c = 80$ K, estimated¹ hole concentration $p = 0.11$) on a log-log plot, together with a power-law fit. The exponent is consistent with 2, within error, in accordance with Fermi-liquid behaviour, and the offset is negligible, indicative of minimal point-disorder effects.

Analysis of published resistivity data for two other cuprates. In order to expand our analysis, we digitized published planar resistivity data² for two underdoped cuprates: detwinned $\text{YBa}_2\text{Cu}_3\text{O}_{6+\delta}$ (YBCO; $T_c = 47$ K, estimated¹ hole concentration $p = 0.09$), and $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ (LSCO; $p = x = 0.10$, $T_c = 28$ K). Importantly, the YBCO resistivity pertains to the direction perpendicular to the CuO chains present in this compound, which means that chain-related complications are expected to be absent. Both compounds exhibit Fermi-liquid behavior in a considerable temperature range above T_c ^{1,2}, which enables the extraction of the paraconductivity as for Hg1201 (Fig. S2). The normal-state resistivity was fit to $\rho = \rho_0 + aT^2$ between 70 and 150 K for YBCO, and between 60 K and 140 K for LSCO. Subsequently, the data were inverted to give the conductivity, and the (inverted) fit result was subtracted to obtain the paraconductivity. In addition, the LSCO paraconductivity was divided by a factor of 2, for the following reason. Within the percolation model, the paraconductivity is inversely proportional to the normal-state resistivity close to T_c (see Eq. (2) in the main text), and therefore the LSCO paraconductivity was scaled to enable comparison with the calculation (the Hg1201 and YBCO samples exhibit similar normal-state resistivities of about $0.1 \text{ m}\Omega\text{cm}$ close to T_c , whereas the corresponding value for LSCO is about $0.2 \text{ m}\Omega\text{cm}$).

Notably, the noise levels for the LSCO and YBCO data are somewhat high due to the digitization procedure and the fact that, unlike in our present work for Hg1201, the focus of Ref. 1 was not to obtain highly precise data close to T_c . Nevertheless, we find remarkable agreement among the three data sets and, in particular, the *same* characteristic temperature scale. This also demonstrates the general applicability of our straightforward normal-state subtraction procedure. Dedicated high-precision resistivity measurements of LSCO and YBCO might reveal possible subtle differences among these cuprate families, but from the available data it is clear that superconducting percolation physics is a universal underlying characteristic of the cuprates. This observation agrees with studies of the nonlinear response in a range of cuprates^{3,4}.

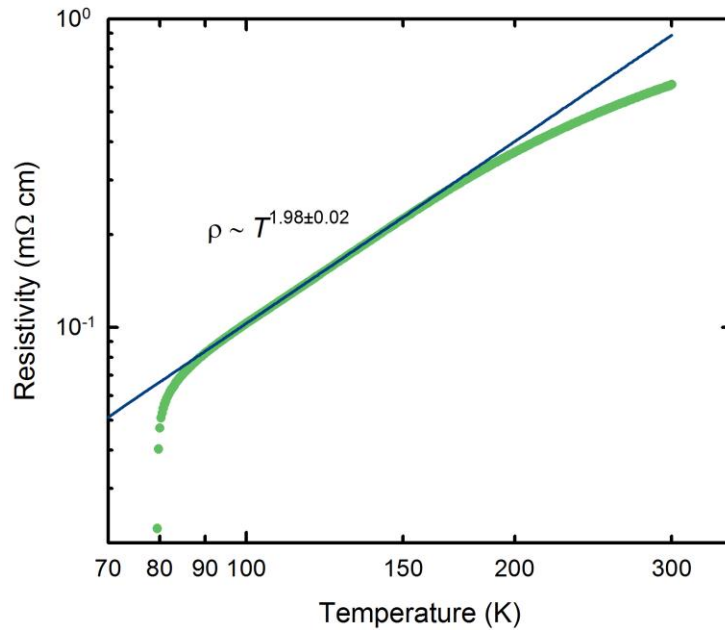


FIG S1. Power-law fit to the normal-state planar resistivity for the Hg1201 sample, demonstrating quadratic behavior over a sizable temperature range, with a negligible residual resistivity of $(-0.3 \pm 1.0) \cdot 10^{-3} \text{ m}\Omega\text{cm}$.

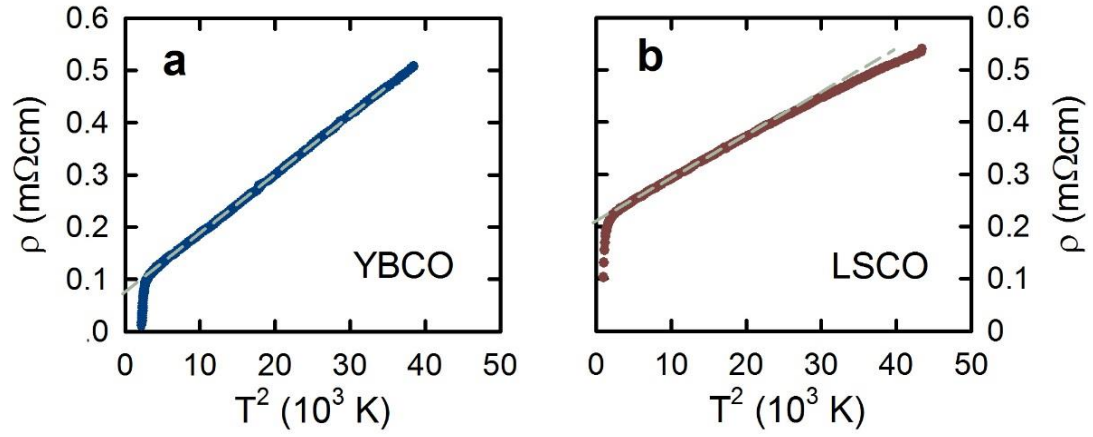


FIG S2. Planar resistivity versus square of temperature for **a** underdoped, detwinned YBCO ($T_c = 47$ K), with current flow perpendicular to the CuO chains, and **b** underdoped LSCO ($T_c = 28$ K). Data digitized from Ref. 2. Both compounds show clear Fermi-liquid behaviour in an extended temperature range (dashed lines).

Supplementary References

¹ Barišić, N. *et al.* Universal sheet resistance and revised phase diagram of the cuprate high-temperature superconductors. *Proc. Natl. Acad. Sci.* **110**, 12235–12240 (2013)

² Ando, Y. *et al.*, Electronic phase diagram of high- T_c cuprate superconductors from a mapping of the in-plane resistivity curvature. *Phys. Rev. Lett.* **93**, 267001 (2004)

³ Pelc, D. *et al.* Emergence of superconductivity in the cuprates via a universal percolation process. Preprint at <https://arxiv.org/abs/1710.10219> (2017)

⁴ G. Yu *et al.* Universal superconducting precursor in the cuprates. Preprint at <https://arxiv.org/abs/1710.10957> (2017)