

1. Background, motivation & method

Layered RP nickelates $R_{n+1}Ni_nO_{3n+1}$ host bulk superconductivity under pressure. ARPES, optics and DFT all imply quasi-2D Fermi surfaces — so $\rho_{\perp}/\rho_{\parallel} \gg 1$ is expected. Yet four-probe dc transport reports $\rho_{\perp}/\rho_{\parallel} < 10$ — current redistribution and contact artifacts mask the intrinsic anisotropy.

We perform axis-resolved dc transport on the same crystal — extracting intrinsic ρ_{\parallel} and ρ_{\perp} to probe how dimensionality, magnetism and superconductivity couple.

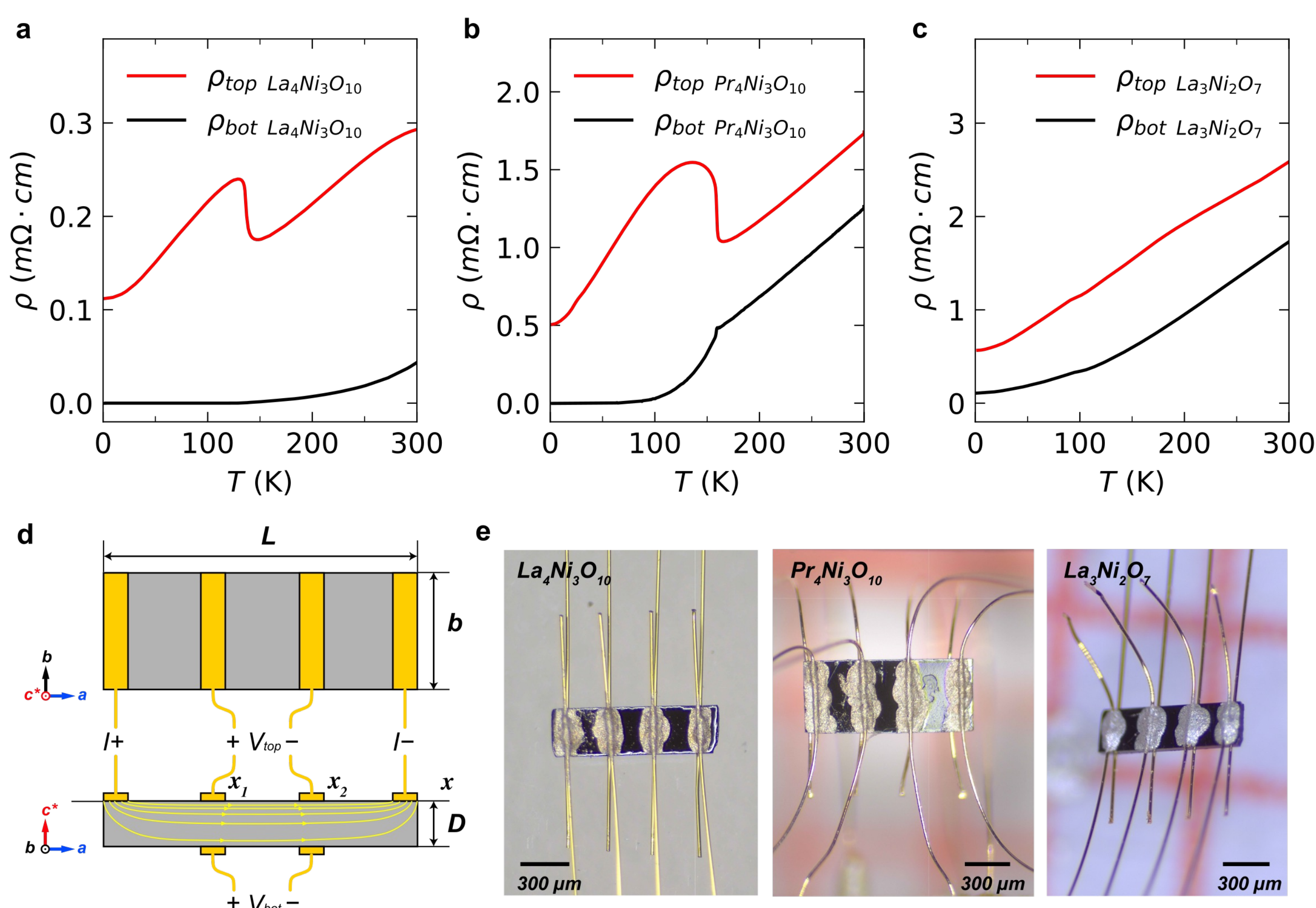
Crystals. $La_3Ni_2O_7$, $La_4Ni_3O_{10}$, $Pr_4Ni_3O_{10}$ grown by high-pressure optical floating-zone furnace; cut into bars $L \approx 0.8–1.1$ mm, $D \approx 40–60$ μm .

Six-terminal geometry. Sputtered Au stripes on top and bottom surfaces; current enters outer contacts, inner top (V_{top}) and bottom (V_{bot}) are read simultaneously.

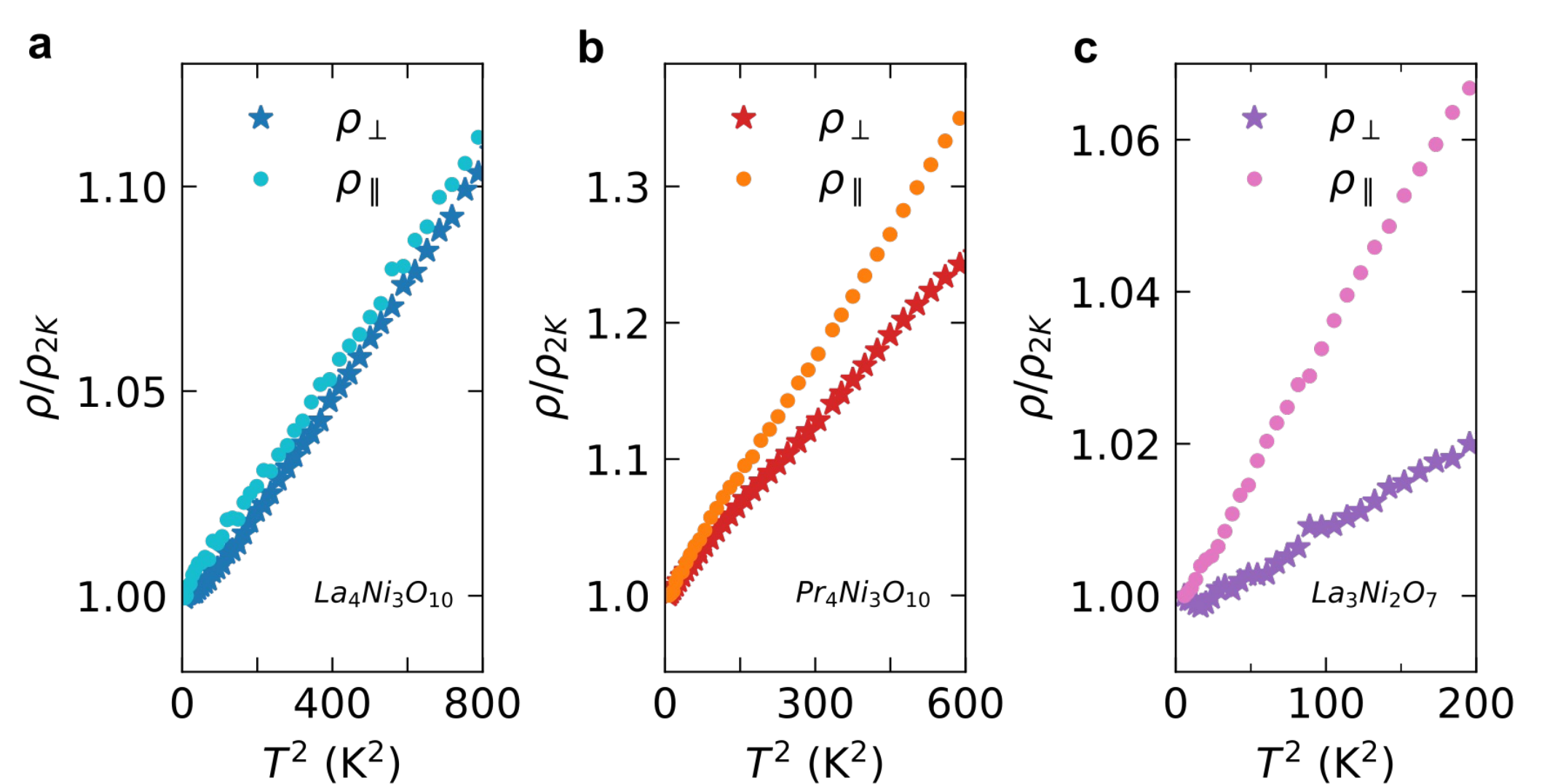
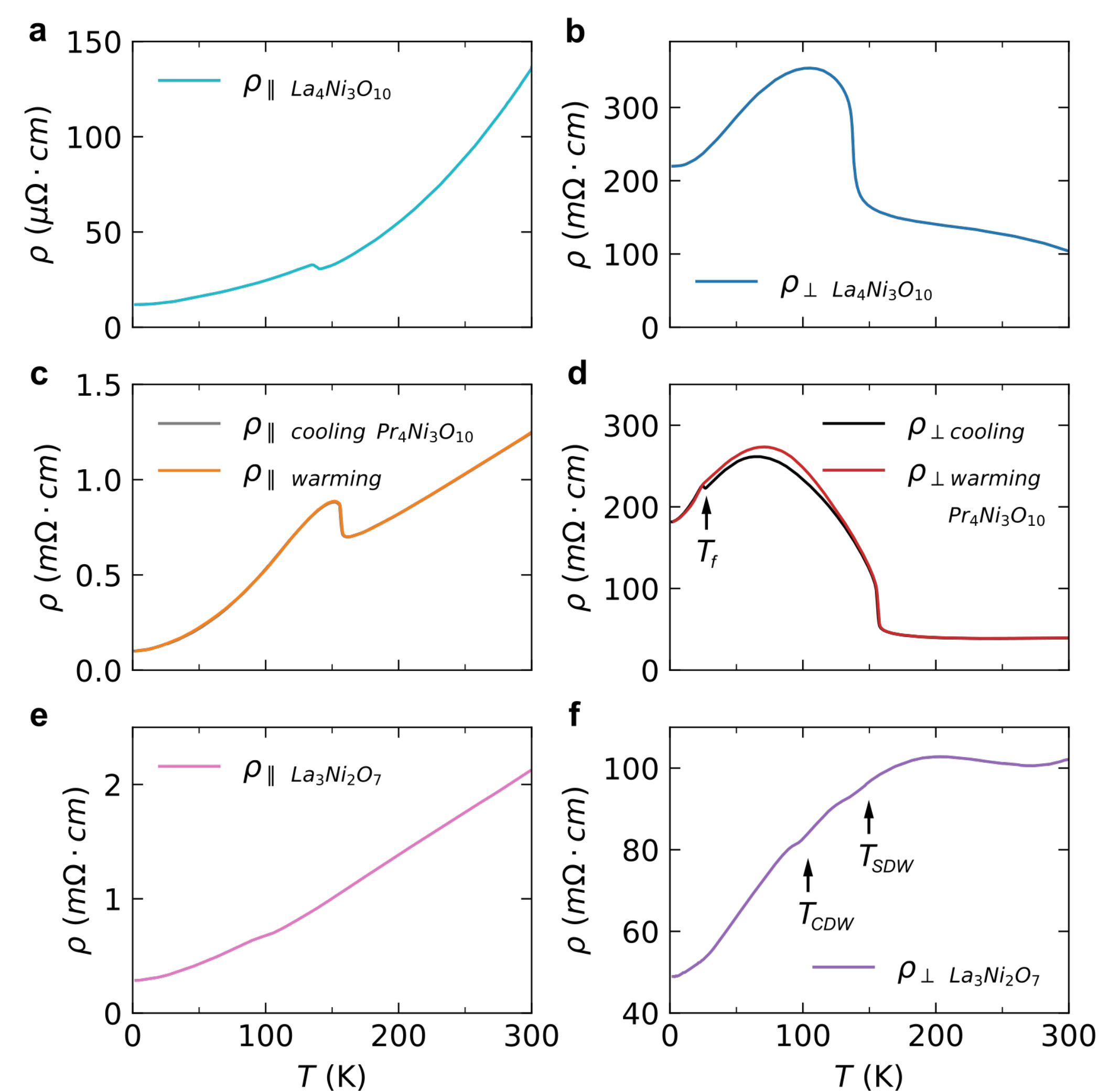
Self-consistent extraction. Solving the Montgomery-type series for $V_{\text{top}}(\rho_{\parallel}, \rho_{\perp})$, $V_{\text{bot}}(\rho_{\parallel}, \rho_{\perp})$ yields intrinsic ρ_{\parallel} and ρ_{\perp} on the same specimen — suppressing geometric and contact artifacts. In ~ 50 μm crystals, $V_{\text{top}} \gg V_{\text{bot}}$ — non-uniform current signals strong anisotropy.

$\rho_{\parallel}(T)$. Metallic with weak DW anomalies (138 / 158 / 110 K). All three recover a Fermi-liquid T^2 regime at low T.

$\rho_{\perp}(T)$. Nonmetallic at high T — incoherent transport. Below the DW transitions ρ_{\perp} rises sharply; at the lowest T a Fermi-liquid T^2 form is recovered — coherent interlayer transport restored.

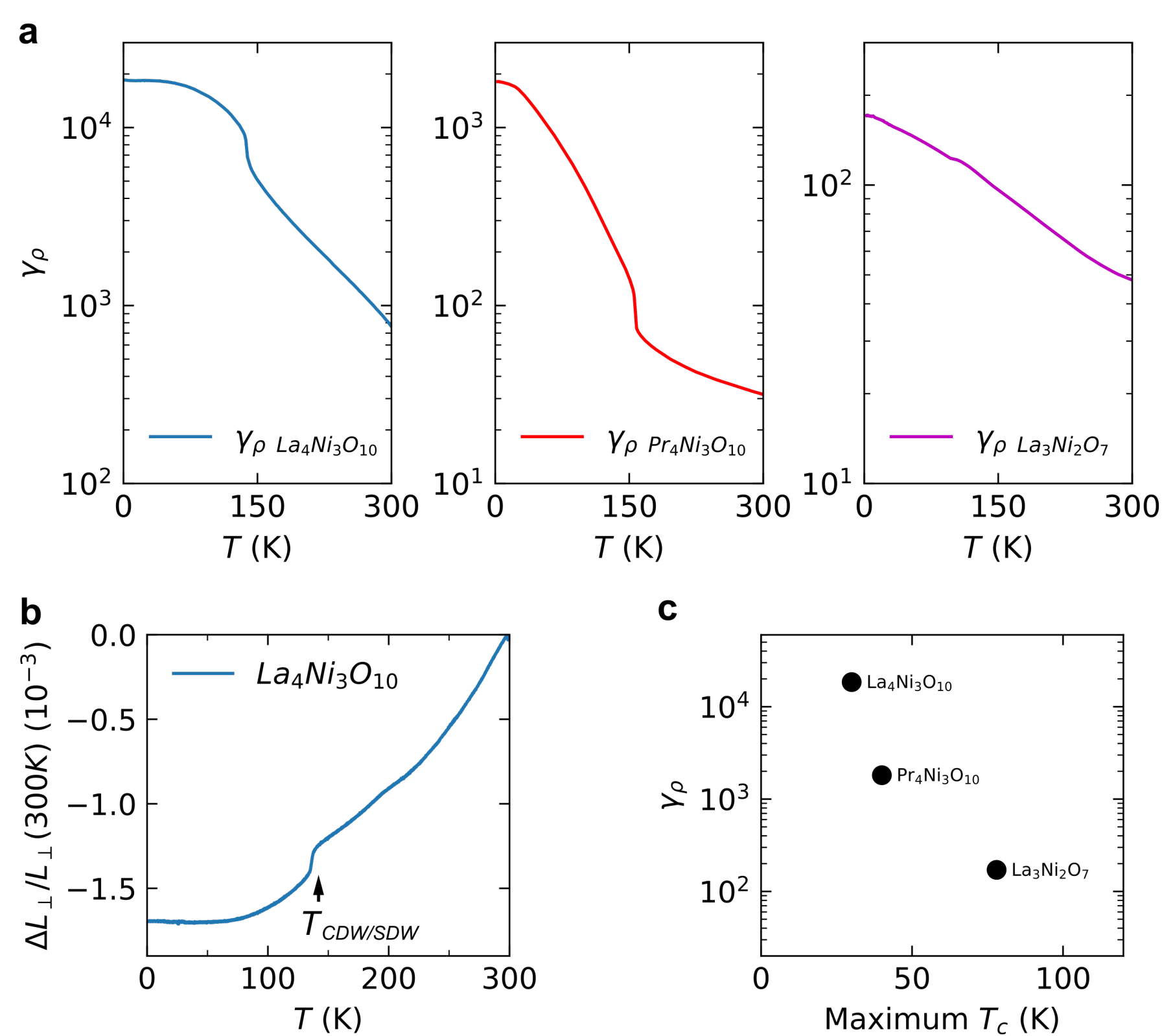


2. Intrinsic ρ_{\parallel} , ρ_{\perp}



- Universal coherent–incoherent crossover; above it the scattering rate exceeds the interlayer hopping scale.
- ρ_{\perp} thus acts as a selective probe of SDW/CDW order — capable of discerning the 3D SDW crossover in $Pr_4Ni_3O_{10}$; the 150 K SDW of $La_3Ni_2O_7$ is essentially absent in ρ_{\parallel} .

3. Anisotropy γ_{ρ} and the link to T_c



(a) $\gamma_{\rho} = \rho_{\perp} / \rho_{\parallel}$

Saturating low-T values: 1.8×10^4 for $La_4Ni_3O_{10}$; 1.8×10^3 for $Pr_4Ni_3O_{10}$; 1.7×10^2 for $La_3Ni_2O_7$.

→ Orders of magnitude larger than earlier reports.

Counter-intuitive layer trend: Bilayer $La_3Ni_2O_7$ is more isotropic than the trilayer compounds — opposite to DFT expectations.

(b) Thermal expansion vs γ_{ρ}

Across the DW transition in $La_4Ni_3O_{10}$ the lattice contracts along c-axis, yet γ_{ρ} rises sharply.

→ Rules out a geometric origin — the anisotropy enhancement is electronic, driven by DW magnetic reconstruction.

(c) Max T_c under pressure vs γ_{ρ}

Across the RP family the pressure-induced max T_c anticorrelates with ambient γ_{ρ} .

→ Stronger interlayer coherence (smaller γ_{ρ}) favors nickelate superconductivity.

CONCLUSIONS

- Six-terminal dc transport reveals quasi-2D anisotropy orders of magnitude larger than previous reports.
- $\rho_{\perp}(T)$ shows a universal coherent–incoherent crossover, and acts as a selective probe of SDW/CDW order via k_{\perp} -dispersive Ni $3d_{z^2}$ states.
- Ambient γ_{ρ} anticorrelates with pressure-induced max T_c — interlayer coherence emerges as the key parameter linking magnetism, dimensionality and superconductivity in RP nickelates.

References

- [1] F. Liu et al., [arXiv:2605.18524](https://arxiv.org/abs/2605.18524) (2026)
- [2] H. Sun et al., Nature **621**, 493 (2023).
- [3] Y. Zhu et al., Nature **631**, 531 (2024)

Acknowledgements

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