Density-wave phases, anisotropic transport, and Planckian dissipation in the superconductor $La_3Ni_2O_7$ single crystals

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Abstract

Pressure-induced superconductivity in the bilayer nickelate $La_3Ni_2O_7$ provides a unique platform for investigating the interplay among density-wave order, charge transport, and unconventional superconductivity [1,2]. However, a quantitative understanding of its normal-state transport properties—including the absolute resistivity, transport anisotropy, and carrier scattering rate—has remained limited, largely because of the lack of accurate measurements on large, high-quality single crystals [1,3].

Here, we establish a high-precision pressure–temperature phase diagram of $La_3Ni_2O_7$ through simultaneous measurements of the in-plane and out-of-plane resistivities of high-quality single crystals under pressure. We identify two distinct density-wave-related anomalies with contrasting pressure dependences [2,4,5]. The pressure-induced structural transition markedly enhances both the low-temperature resistivity and transport anisotropy [6], revealing a strong influence of density-wave order on anisotropic charge transport. Zero-resistance superconductivity emerges near the pressure regime where the density-wave anomalies become strongly suppressed. At higher pressures, the normal-state resistivity exhibits robust linear-in-temperature behavior over a broad temperature range, with a carrier scattering rate comparable to the Planckian dissipation scale. These results demonstrate that pressure profoundly reorganizes anisotropic charge transport through the evolution of multiple density-wave instabilities, ultimately giving rise to a pronounced strange-metal state from which superconductivity emerges. Our work establishes robust density-wave correlations and Planckian dissipation as key characteristics of superconducting $La_3Ni_2O_7$ [5].

References

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Biography



Dr. Zhehong Liu received his Ph.D. from the Institute of Physics (IOP), Chinese Academy of Sciences (CAS), in 2021. From 2021 to 2023, he worked as a postdoctoral researcher at IOP, CAS, supported by the China Postdoctoral Innovative Talent Program. Since 2023, he has been a postdoctoral researcher at RIKEN, Japan.

His research focuses on novel transition-metal oxides, particularly A-site-ordered quadruple perovskites and nickelate single crystals synthesized under high pressure and high temperature. He uses techniques, such as synchrotron X-ray diffraction, high-pressure electrical transport measurements and so on, to study their crystal structures and physical properties, including spin states, valence states, spin and charge ordering, and superconductivity.

He has extensive experience in high-pressure crystal growth, solid-state synthesis, and the study of structure–property relationships in transition-metal oxides. In particular, during his time in the Yoshinori Tokura and Yasujiro Taguchi Group, he achieved a series of research advances in the controlled growth of high-quality nickelate superconducting single crystals and their high-pressure transport and structural properties.

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