Partial recovery of the normal state at the T_0 phase boundary in $CeRh_2As_2$

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Among Ce-based heavy-fermion superconductors, $CeRh_2As_2$ has attracted considerable attention due to its remarkably complex low-temperature phase diagram, featuring multiple superconducting phases and field-induced switching between them. The compound has emerged as a particularly rich playground for studying the interplay between unconventional superconductivity, magnetism, and locally broken inversion symmetry. Importantly, superconductivity in $CeRh_2As_2$ does not emerge from a simple paramagnetic metal: it is preceded by an additional, enigmatic phase transition at $T_0 \approx 0.5$ K, whose microscopic character remains actively debated. Initially proposed as a quadrupole density-wave state associated with multipolar degrees of freedom [1], this transition has more recently been shown to carry clear signatures of magnetic order [2, 3]. Understanding the origin of this phase seems essential to explaining the unconventional superconducting properties of $CeRh_2As_2$.

In this contribution, we briefly review the current understanding of the T_0 phase in $CeRh_2As_2$ and present our recent transport measurements. These ultra-low-temperature magnetotransport experiments were performed on focused-ion-beam (FIB)-fabricated microstructures of $CeRh_2As_2$. For a magnetic field applied along the crystallographic *c*-axis, the resistivity reveals an unusual evolution near the boundary of the T_0 phase. In a narrow temperature range, two distinct zero-resistance regions are observed as a function of magnetic field. Starting from the low-field superconducting state, superconductivity is first suppressed, leading to a partial recovery of the normal state with finite resistivity. Upon further increasing the field and crossing the edge of the T_0 phase, superconductivity reappears, giving rise to a second zero-resistance state. The resulting S-shaped temperature–magnetic-field phase diagram is reminiscent of those found in uranium-based ferromagnetic superconductors UGe_2, UCoGe, and URhGe, where this reentrant superconductivity is closely tied to a competing magnetic order. This analogy suggests that the T_0 phase is likely involved in the evolution of superconductivity in $CeRh_2As_2$.

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References

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