Colloquium

Mysteries of the two-phase superconductor CeRh2As2

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Abstract:Superconductors with non-trivial pairing symmetries expand our understanding of correlated quantum matter and show promise for applications in quantum computing. Odd-parity superconductivity is interesting in this regard due to its robustness to magnetic field and possible topological surface states. The phenomenon only occurs in a few materials, the most recognised cases of which are strongly correlated uranium-based systems with weak ferromagnetism. Another candidate is CeRh2As2, which exhibits a magnetic-field-induced transition between two superconducting phases, currently understood as states of even- and odd-parity pairing. Here, the odd-parity pairing is thought to be stabilisied not by ferromagnetism, but by the staggered Rashba spin-orbit interaction caused by the absence of inversion symmetry at the Ce sites. Since the tetragonal crystal structure is centrosymmetric, states of distinct parity are allowed [1,2]. But the superconductivity is not the only mystery of CeRh2As2. Similarly to other unconventional superconductors, the material hosts a coexisting weak ordered state that can be suppressed by pressure [3-5]. Although the order parameter is not fully identified, internal magnetic fields are evidenced by NMR/NQR [6] and muSR [7] measurements. Intriguingly, the transition temperature decreases with the out-of-plane field, but increases strongly with the in-plane field, which is hard to reconcile with a simple magnetic order but can be explained by considering quadrupolar degrees of freedom [3,8]. This unconventional magnetic state and its role for superconductivity are currently in the focus of research on this compound. In my talk, I will highlight experimental results from macroscopic and microscopic measurements under different tuning parameters such as pressure and magnetic field, each nurturing our current understanding of the fascinating properties of CeRh2As2. References [1] S. Khim & J. Landaeta et al., Science 373, 1012–1016 (2021). [2] J. Landaeta et al., Phys. Rev. X 12, 031001 (2022). [3] D. Hafner et al., Phys. Rev. X 12, 011023 (2022). [4] M. Pfeiffer et al., Phys. Rev. Lett. 133, 126506 (2024). [5] K. Semeniuk et al., Phys. Rev. B 110, L100504 (2024). [6] M. Kibune et al., Phys. Rev. Lett. 128, 057002 (2022).[7] S. Khim et al., Phys. Rev. B 111, 115134 (2025).[8] B. Schmidt and P. Thalmeier, Phys. Rev. B 110, 075154 (2024).

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