



Colloquium

Mysteries of the two-phase superconductor CeRh_2As_2

Elena Hassinger

TU Dresden

Host: Kimberly Modic

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 CeRh_2As_2 , 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 stabilised 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 CeRh_2As_2 . 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 μSR [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 CeRh_2As_2 . 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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