TT 52: Heavy Fermions

Time: Wednesday 15:00–16:30 Location: HSZ/0103

TT 52.1 Wed 15:00 HSZ/0103

High-field muon spin resonance/rotation (μSR) studies on $CeRh_2As_2$ — •Seunghyun Khim[1], Oliver Stockert[1], Andrin Doll[2], and Robert Scheuermann[2] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Paul Scherrer Institute, Villigen, Switzerland

The heavy-fermion $CeRh_2As_2$ with $T_c = 0.35$ K exhibits unique two-phase superconductivity under a c-axis magnetic field. In the superconducting (SC) state, a field-induced transition at $H^* = 4$ T separates a low-field even-parity (SC1) phase from a high-field odd-parity (SC2) phase. In addition, an unusual ordering of the Ce-4f moments emerges below $T_0 = 0.55$ K, which is suppressed with increasing c-axis field. The T_0 phase boundary smoothly extends into the SC2 phase and persists to zero temperature at approximately 7 T. Previous zero-field μSR studies have identified that an internal field develops spontaneously below T_0 and becomes nearly saturated below T_c, suggesting a possible correlation between the magnetic order and superconductivity. Here, we present following high-field μSR measurements up to 7.5 T. Temperature-dependent measurements at 2 T show that the internal field is fully established below 0.3 K, coinciding with the onset of the SC1 phase. Furthermore, field-dependent measurements at 20 mK reveal that the internal field begins to be suppressed above 4 T and then vanishes entirely at around 7 T. These observations propose that the magnetic order in the T_0 phase is locked in exclusively within the SC1 phase, reflecting an intricate coupling between the magnetic and SC order parameters.

TT 52.2 Wed 15:15 HSZ/0103

Coupled magnetic and quadrupolar order in tetragonal $CeRh_2As_2$ evidenced by the basal-plane anisotropy — •Konstantin Semeniuk[1,2], Burkhard Schmidt[2], Seunghyun Khim[2], and Elena Hassinger[1,2] — [1]Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany — [2]Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany

Unconventional superconductivity in Ce-based Kondo-lattice materials has been known to emerge exclusively in the vicinity of weak dipolar magnetic orders, while higher-order multipolar orders are only known to occur in a few Pr-based unconventional superconductors and possibly URu_2Si_2. Moreover, for tetragonal Ce-based compounds, quadrupolar orders are disfavoured by a two-fold degenerate ground state of the crystal electric field scheme, in contrast to a four-fold degenerate one in cubic systems. The multiphase superconductor $CeRh_2As_2$ appears to be a notable exception from both of these trends by possibly hosting coupled magnetic and quadrupolar orders. In this talk, we explain how such a scenario can be realised [1,2] and show that the field-temperature phase diagram of $CeRh_2As_2$ has a pronounced basal-plane anisotropy, which effectively proves the existence of higher-order multipolar ordering and raises questions regarding its role in the superconducting pairing.

[1] D. Hafner et al., Phys. Rev. X, 12, 011023 (2022).
[2] B. Schmidt, P. Thalmeier, Phys. Rev. B 110, 075154 (2024).

TT 52.3 Wed 15:30 HSZ/0103

Pressure evolution of coplanar antiferromagnetism in heavy-fermion $Ce_2CoAl_7Ge_4$ — •Mukkattu O. Ajeesh[1,2], Allen O. Scheie[1], Yu Liu[1], Lucas Keller[3], Sean M. Thomas[1], Priscila F. S. Rosa[1], and Eric D. Bauer[1] — [1]Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA — [2]Department of Physics, Indian Institute of Technology Palakkad, Kerala 678623, India — [3]Laboratory for Neutron Scattering and Imaging, Paul Scherrer Institut, Villigen CH-5232, Switzerland

$Ce_2MAl_7Ge_4$ (M = Co, Ir, Ni, or Pd) compounds are heavy-fermion materials that exhibit a variety of ground states ranging from magnetism to non-Fermi-liquid behavior. The Co, Ir, and Ni members undergo magnetic ordering with decreasing transition temperatures across the series. In contrast, the Pd compound shows no magnetic order down to 0.4 K and exhibits non-Fermi-liquid behavior, indicating proximity to a magnetic quantum critical point. Among these materials, $Ce_2CoAl_7Ge_4$ orders antiferromagnetically below $T_N = 1.9$ K and displays heavy-fermion behavior below 15 K. We investigated the magnetic structure of its antiferromagnetic phase along with the evolution of the magnetic transition under external pressure. Resistivity and ac calorimetry measurements under hydrostatic pressure reveal that T_N is suppressed to 1 K at $p \approx 1$ GPa, above which the transition abruptly disappears in a first order-like fashion. These results highlight that transition metal substitution is not merely a lattice volume effect akin to applied pressure; instead, carrier doping and anisotropic changes in lattice parameters likely play important role.

TT 52.4 Wed 15:45 HSZ/0103

Tuning the ground state of CePdAl by hydrogenation — Hailiang Xia, Jitong Song, He Sun, Zhaotong Zhuang, Junsen Xiang, Shuai Zhang, and •Peijie Sun — Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China

CePdAl is an antiferromagnetic heavy-fermion compound crystallizing in a geometrically frustrated Kagome lattice. We have succeeded in hydrogen doping the bulk single-crystalline CePdAl by an ionic liquid gating technique, resulting in a large lattice expansion of the c axis by more than 20%. The hydrogen-doped sample $CePdAlH_x$ is stable in air, and can be subject to various ex-situ transport, magnetic and thermodynamic measurements down to very low temperatures. Hydrogen distribution in CePdAl significantly alters the crystal electric field, reducing the Ising-like magnetic anisotropy, and the antiferromagentic transition temperature T_N is reduced from 2.7 K to 1.1 K. Intriguingly, the Kondo effect remains almost intact. We discuss the results in view of a local and anisotropic negative pressure effect realized by hydrogenation.

TT 52.5 Wed 16:00 HSZ/0103

Intertwined magnetic and superconducting orders in Ce_3PtIn_{11} — Jan Fikáček[1], Sarah R. Dunsiger[2], Andrea D. Bianchi[3], Manuel Brando[4], Laurent Nicolai[5], Aki Pulkkinen[5], and •Jeroen Custers[1] — [1]Charles University, Faculty of Mathematics and Physics, Dept. Condensed Matter Physics, Prague, Czech Republic — [2]Centre for Molecular and Materials Science, TRIUMF, Vancouver, Canada — [3]Département de Physique, Université de Montréal, Montréal, Canada — [4]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [5]New Technologies Research Centre, University of West Bohemia, Pilsen, Czech Republic

The heavy fermion compound Ce_3PtIn_{11} exhibits intriguing low-temperature properties. At ambient pressure, it undergoes two successive antiferromagnetic (AFM) transitions at $T_{N1} = 2.2$ K and $T_N = 2.0$ K. Superconductivity (SC) emerges below $T_c = 0.32$ K (J. Prokleška *et al.*, Phys. Rev. B **92,** 161114(R) (2015)). The coexistence of AFM and SC has been proposed, attributed to the presence of two inequivalent Ce sites whose distinct local environments may stabilize either magnetic or superconducting order. In this work, we focus on the superconducting state, presenting specific heat measurements and recent muon spin rotation experiments performed at ambient pressure down to 20 mK, complemented by band-structure calculations. Together, these results reveal signatures of an unconventional SC state coexisting with magnetism.

Work is supported by the Czech Ministry for Education, Youth and Sports program INTERCOST (Grant No. LUC24139).

TT 52.6 Wed 16:15 HSZ/0103

Coupling between Kondo effect and in-plane strain in $YbRh_2Si_2$ — •Soumendra Nath Panja, Jacques G Pontanel, Julian Kaiser, Anton Jesche, and Philipp Gegenwart — Experimental Physics VI, Center for Electronic Correlations and Magnetism, University of Augsburg, 86159 Augsburg, Germany

We study symmetry-resolved elastoresistance in the tetragonal Kondo lattice $YbRh_2Si_2$ down to 2 K and in fields up to 14 T. By measuring longitudinal and transverse electrical transport response under applied in-plane uniaxial strain along [100] and [110], we extract the A_{1g}, B_{1g}, and B_{2g} elastoresistive responses. This is complemented by high-resolution in-plane thermal-expansion measurements utilizing a novel sample-mounting strategy for thin crystals in the capacitive dilatometer. Our results establish a thermodynamic link to the strain-dependent electronic behavior and highlight how Kondo hybridization couples to in-plane strain in this heavy-fermion system.