TT 58: f-Electron Systems and Heavy Fermions

Time: Friday 11:30–13:00 Location: H31

TT 58.1 Fri 11:30 H31

The in-plane magnetic anisotropy of the coupled antiferromagnetic and charge-multipolar orders in $CeRh_2As_2$ — •Konstantin Semeniuk[1], Seunghyun Khim[1], and Elena Hassinger[1,2] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Dresden University of Technology, Institute for Solid State and Materials Physics, Dresden, Germany

The heavy-fermion superconductor $CeRh_2As_2$ displays multiple intriguing electronic orders (1,2). Besides two superconducting phases, the material also hosts a state called Phase I at temperatures below $T_0 = 0.5$ K. Phase I exhibits magnetism (3), but the response of T_0 to a magnetic field H along the ab plane of the tetragonal lattice is incompatible with conventional magnetic orders. In particular, while $T_0(H)$ is rather stable in Phase I, at a critical field H_{cr} the material transitions into Phase II, in which T_0 rapidly increases with field.

We conducted a detailed investigation of the H-T phase diagram of $CeRh_2As_2$ for various in-plane field orientations. The behaviour of $T_0(H)$ is remarkably different for $H||[100]$ and $H||[110]$, with, respectively, suppression and enhancement of T_0 in Phase I, as well as strong anisotropy of H_{cr}. In line with recent theoretical work (4), we regard Phase I as a unique case of coupled antiferromagnetic and charge-multipolar orders, and use our results to constrain the model.

[1] S. Khim et al., Science **373**, 1012 (2021).
[2] D. Hafner et al., Phys. Rev. X **12**, 011023 (2022).
[3] S. Khim et al., arXiv:2406.16575.
[4] B. Schmidt & P. Thalmeier, Phys. Rev. B **110**, 075154 (2024).

TT 58.2 Fri 11:45 H31

Complex magnetic order from multiple Ce–sites in $CeRhSn_2$. — Petr Opletal[1], Jan Fikáček[1], Arumugam Thamizhavel[2], Zakir Hossain[3], Róbert Tarasenko[4], Vladimír Tkáč[4], and •Jeroen Custers[1] — [1]Charles University, MMF DCMP, Prague, Czech Republic — [2]DCMP & MS, Tata Institute of Fundamental Research, Mumbai, India — [3]Dept. of Physics, Indian Institute of Technology, Kanpur, India — [4]Institute of Physics, Faculty of Science, P.J. Šafárik University, Košice, Slovak Republic

Previous reports on polycrystalline $CeRhSn_2$ reveal different magnetic ground states being ferromagnetic ($T_C = 4$ K) or antiferromagnetic ($T_N = 3.5$ K). To elucidate we have grown a single crystal and conducted measurements of the magnetization (M), specific heat (C_p/T), and electrical resistivity (ρ). The compound crystallizes in the orthorhombic lattice structure with space group $Cmcm$ characterized by the cell parameters $a = 4.5905(10)$Å, $b = 16.9758(5)$Å and $c = 9.5924(3)$Å. Moreover, it exhibits two crystallographic inequivalent Ce–sites with a zigzag chain of Ce–atoms running along the c–axis. Our measurements reveal an AFM phase transition at $T_{M1} = 3.6$ K manifesting by a strong decrease of the orthorhombic c–axis magnetization, while only a tiny cusp is notable along the other directions, a sharp discontinuity in C_p/T and a kink in ρ and a subsequent ferrimagnet–like (FIM) ordering at $T_{M2} = 1.7$ K visible by a λ-shape of peak in C_p/T and a sudden drop in the resistivity. We map out a B–T phase diagram for field $B \parallel b$–axis and follow the evolution of the transitions under hydrostatic pressure up to 3 GPa.

TT 58.3 Fri 12:00 H31

Anderson impurity model calculations for line shape analyses of core to valence RIXS spectra of Ce Kondo materials — •Michelangelo Tagliavini[1], Federico Mazza[2], Xinlin Yan[2], Andrey Prokofiev[2], Kurt Kummer[3], Maurits W. Haverkort[1], and Silke Paschen[2] — [1]*Institute for Theoretical Physics (ITP), Heidelberg University*, Philosophenweg 19, 69120, Heidelberg, Germany — [2]*Institute of Solid State Physics, Vienna University of Technology*, Wiedner Hauptstr. 8-10/138 A 1040 Vienna, Austria — [3]*European Synchrotron Radiation Facility*, 71 Avenue des Martyrs, CS40220, F-38043 Grenoble Cedex 9, France

In rare-earth-containing heavy-fermion compounds, the interaction of continuum electrons with 4f local moments can give rise to a Kondo screened ground state. Crystal-field excited states can be probed using Resonant Inelastic X-ray Scattering (RIXS). Interaction between localized 4f states and continuum electrons transforms the crystal-field excitations into resonances with hybridization-dependent asymmetric line shapes. In this study, we present results for two heavy-fermion compounds: $CeBa_7Au_6Si_{40}$ and $CeRu_4Sn_6$, which exhibit low (≈1 K) and high (≈ 200 K) Kondo temperatures, respectively. Using density-functional-theory-based Anderson impurity model calculations implemented in Quanty (www.Quanty.org), we link the f-f transition line shapes to the hybridization function in these materials. Our findings reveal a direct relationship between the hybridization function, the Kondo temperature, and the crystal fields, offering new insights into the underlying physics of these complex systems.

TT 58.4 Fri 12:15 H31

Emergent in-plane anisotropic elastoresistance in $YbRh_2Si_2$ — •Soumendra Nath Panja, Jacques Gounelle-Pontanel, Anton Jesche, and Philipp Gegenwart — Experimental Physics VI, Center for Electronic Correlations and Magnetism, University of Augsburg, 86159 Augsburg, Germany

We have shown recently that the Kondo interaction in the tetragonal heavy-fermion metal $YbRh_2Si_2$ can be efficiently tuned by tensile and compressive uniaxial strain along the [100] axis [1]. Here, we present a detailed investigation of the temperature dependent elastoresistance $d\rho/d\epsilon_i$ of $YbRh_2Si_2$, for both i=[100] and [110] directions. Remarkably, elastoresistance develops a pronounced in-plane strain anisotropy at low temperatures that is analyzed with respect to the influence of uniaxial strain on the crystal electric field splitting and Kondo interaction. Furthermore, we investigate the combined impact of magnetic field and strain on the low-temperature elastoresistance behavior in $YbRh_2Si_2$.

[1] S.N. Panja, A. Jesche, N. Tang, P. Gegenwart, Phys. Rev. B **109**, 205152 (2024).

TT 58.5 Fri 12:30 H31

Anisotropic antiferromagnetic order in $EuPd_3Si_2$ — •Michelle Ocker[1], Nour Marayatta[2], Michael Merz[2], Kristin Kliemt[1], and Cornelius Krellner[1] — [1]Physikalisches Institut, Goethe Universität Frankfurt, 60438 Frankfurt/Main, Germany — [2]Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany

The magnetic order of a rare earth compounds is determined by the RKKY exchange interaction. In case of Eu compounds small changes in the growth method or the initial composition can potentially lead to small composition changes which than modify the physical properties [1]. For example, the compound $EuPd_3Si_2$, which crystallises in the orthorhombic space group Imma, shows a ferromagnetic transition at $T_{C1} = 78$ K and a spin reorientation at $T_{C2} = 5$ K according to Ref. [2]. Whereas our $EuPd_3Si_2$ samples show an antiferromagnetic transition at $T_{N1} = 61$ K and a possible reorientation at $T_{N2} = 40$ K. With field aligned along the three main symmetrie directions, our samples show different degrees of anisotropy, as has been observed for related compounds [3]. In this presentation, we report about the crystal growth and our evaluation of the physical properties, from which we constructed a magnetic phase diagram.

[1] K.Kliemt et al. Cryst. Growth Des. 22, 5399 (2022).
[2] S.Sharma et al. Phys. Rev. Mater. 7, 023402 (2023).
[3] K.Shigetoh et al. Phys. Rev. B 76, 184429 (2007).

TT 58.6 Fri 12:45 H31

Coherent valence dynamics in UAl_3 — •Vinicius Estevo Silva Frehse[1], Hlynur Gretarsson[2], Eric Bauer[3], Atsushi Hariki[4], Filip Ronning[3], and Marein Rahn[1] — [1]Center for Electronic Correlations and Magnetism, Augsburg, Germany — [2]P01 High Resolution Dynamics Beamline, Hamburg, Germany — [3]Institute for Materials Science, Los Alamos, USA — [4]Department of Physics and Electronics, Osaka, Japan

The interaction between itinerant and localized electrons, as proposed by the Kondo model, enables the formation of heavy fermions, and unconventional superconductivity. In f-electron intermetallics with a large Kondo temperature, the emergence of lattice-coherent valence dynamics can be resolved by resonant inelastic x-ray scattering (RIXS). In the simple cubic, strongly valence fluctuating compound UAl_3, a coherent Fermi surface of Kondo quasiparticles emerges around $T_{coh} \sim 200$ K. We study the excitations of these quasiparticles using the newly available RIXS instrumentation for the tender x-ray range. The spectra indeed reveal dispersive trends of the $5f$ interband excitations at low temperatures, reminiscent of the isostructural $4f$ compound $CePd_3$[1]. [1] M.C.Rahn, *et al.*, Nat. Comm. **13**, 6129 (2022).