TT 62: Correlated Electrons – Poster II

Time: Wednesday 15:00–17:00 Location: P4

TT 62.1 Wed 15:00 P4

Interplay of electronic and magnetic properties of single crystal Nd — •Markus Brauner[1], Ivan Volkau[1], Lukas Bauer[1], Andreas Bauer[1,3], Christian Pfleiderer[1,2,3], and Marc A. Wilde[1,3] — [1]Technical University of Munich (TUM) — [2]MCQST, Munich — [3]TUM Zentrum für QuantumEngineering

The rare earth Neodymium hosts a wide range of multi-Q magnetic phases at temperatures below 20K and fields up to 4T [1]. Recently, Neodymium was found to exhibit a previously unknown spin glass behavior in bulk-like thick films [2]. We study the interplay of magnetism and the electronic structure of bulk single crystal samples grown with the Czochralski method and map the magnetic phase diagram of Nd using vibrating sample magnetometry. First results of Fermi surface study using Shubnikov-de Haas measurements and Density Functional Theory calculations will be presented.

[1] S W Zochowski et al., J. Phys.: Condens. Matter 3, 8079 (1991)
[2] U. Kamber et al. Science 368, eaay6757 (2020).

TT 62.2 Wed 15:00 P4

Magnetic polarons in antiferromagnetic $EuCd_2P_2$ with systematic impurities — •Dominik Hoff, Julian Beu, Sarah Krebber, Kristin Kliemt, Cornelius Krellner, and Jens Müller — Goethe-University Frankfurt, Germany

Strong interactions between charge carriers and magnetism can give important insights on the physics of correlated electron systems. The colossal magnetoresistance (CMR) is one such effect, that is promising for applications. We are investigating $EuCd_2P_2$, which shows a strong CMR-effect above its antiferromagnetic transition [1]. In previous works, it was possible to link the CMR-effect to the existence and percolation of magnetic polarons resulting in a strong increase in low-frequency resistance fluctuations at the CMR-peak caused by the onset of polaron percolation. It was also found that the CMR-effect of $EuCd_2P_2$ is strongly sensitive to the sample's growth conditions [2]. To further examine these dependencies, we investigate systematic structural differences in the form of chemical substitutions. In this work we aim to investigate behavioural changes of magnetic polarons due to the substitution of Silicon in the growth process of $EuCd_2P_2$. We analyze the Hall effect, higher-harmonic resistance and resistance fluctuations as a function of temperature and magnetic field aiming to systematically determine the impact of structural impurities on polaron dynamics.

[1] Phys. Rev. B 109 (2024) 104421
[2] arXiv2503.24059

TT 62.3 Wed 15:00 P4

Noise spectroscopy on $EuZn_2P_2$ and $Sm_{1-x}Eu_xB_6$ — •Kristijan Verusheski[1], Julian Beu[1], Sarah Krebber[1], Kristin Kliemt[1], Cornelius Krellner[1], Steffen Wirth[2], Priscila Rosa[3], and Jens Müller[1] — [1]Physikalisches Institut, Goethe Universität Frankfurt, Germany — [2]Max Planck Institute for Chemical Physics of Solids Dresden, Germany — [3]Los Alamos National Laboratory, Los Alamos, NM 87545, USA

The colossal magnetoresistance (CMR) effect is of great interest because it emerges in correlated electron systems, e.g. in Eu-based antiferromagnets such as $EuZn_2P_2$ and $EuCd_2P_2$. For these materials a set of dynamical measurements revealed that the CMR effect is most likely driven by formation and percolation of magnetic polarons [1,2,3]. While both systems exhibit a pronounced CMR effect, they differ considerably in their carrier density and resistivity behaviour, resulting in markedly different transport properties. In this work, $EuZn_2P_2$ is examined in detail where we aim to investigate how magnetic polarons form, evolve and dissolve through non-linear transport and resistance fluctuation spectroscopy measurements. Similary, magnetic polarons can be studied in $Sm_{1-x}Eu_xB_6$. The antiferromagnetic composition $Sm_{0.1}Eu_{0.9}B_6$ shows a pronounced hysteresis in the MR curve [4], which likely indicates field-induced polaron stabilization.

[1] Rev. B 108, 045116 (2023)
[2] Phys. Rev. B 109, 104421 (2024)
[3] arXiv:2503.24059
[4] Condens. Matter 9, 55 (2024).

TT 62.4 Wed 15:00 P4

Growth and Structural Characterization of $NdCo_2P_2$ Single Crystals for Site-Resolved Magnetic Studies — •Francesca Martino[1,2], Benjamin Helmer[1], Kristin Kliemt[1], Kurt Kummer[2], and Cornelius Krellner[1] — [1]Physikalisches Institut, Goethe-Universität Frankfurt, Frankfurt am Main, Germany — [2]European Synchrotron Radiation Facility (ESRF), Grenoble, France

Rare-earth intermetallics with both 3d transition-metal and 4f rare-earth magnetic moments exhibit rich and often unexpected magnetic phenomena. Indeed, different intriguing properties have been found in the $LnCo_2P_2$ family [1][2]. As a first step towards exploring these interactions in $NdCo_2P_2$, high-quality single crystals have been successfully grown. In this study, we present an optimized growth procedure, confirmed by structural characterization via X-ray diffraction (XRD) and energy-dispersive X-ray spectroscopy (EDX), which demonstrates a well-ordered $ThCr_2Si_2$-type structure with high phase purity. Thermodynamic and transport measurements have also been performed to further assess the properties of the samples. These well-prepared single crystals provide a solid foundation for forthcoming site-specific X-ray magnetic spectroscopy studies, aiming to disentangle the contributions of the Nd and Co sublattices and to explore the complex magnetic behavior inherent to the $LnCo_2P_2$ series.

[1] G. Poelchen et al., ACS Nano 16, 3573(2022).
[2] C. Thompson et al., J. Mater. Chem. C2 (2014).

TT 62.5 Wed 15:00 P4

Locally non Centrosymmetric $R$$Rh_2Ga_2$ (R=Ce, La) Systems: NMR/NQR as local probe for Magnetism and Superconductivity — •I. Neme[1], A. M. Strydom[2], D. T. Adroja[3], V. K. Anand[3,4], H. Rosner[1], and M. Baenitz[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Physics Department, University of Johannesburg, South Africa — [3]ISIS Facility, Rutherford Appleton Laboratory, Chilton, UK — [4]Department of Physics, National Institute of Technology Agartala, Tripura, India

$CeRh_2Ga_2$ belongs to the class of locally non-centrosymmetric (LNC) correlated Ce Kondo systems [1] and is closely related to the recently discovered superconductor $CeRh_2As_2$ [2]. The non-magnetic reference $LaRh_2Ga_2$ is superconducting with relatively high T_c of 3.7 K, in contrast with 0.28 K for $LaRh_2As_2$. We have performed ^{69,71}Ga, ^{139}La NMR and ^{69,71}Ga NQR studies to probe the magnetism and the superconductivity. For characterization, we present magnetization and heat capacity measurements. Calculations of the band structure and the local electric field gradient at the Ga and La sites support our experimental results. We discuss the magnetic ground state of the Ce system and the occurrence of superconductivity in the La reference on basis of correlations and LNC properties.

[1] V. K. Anand et al., J. Phys. Cond. Matt. 29 (2017)
[2] S. Khim et al., Science 373 (2021)

TT 62.6 Wed 15:00 P4

Exploring the reciprocal space of $CeRh_2As_2$ at a high brilliance SwissFEL beamline — •Alexander Mistonov[1], Jakub Vonka[2], Alexander Steppke[2], Swarnamayee Mishra[1], Maël Clémence[2], Adrian Rutschmann[2], Karina Kazarian[2], Wenxiang Hu[2], Bill Pedrini[2], Simon Gerber[2], Elena Hassinger[3], Seunghyun Khim[4], and Jochen Geck[1] — [1]TU Dresden, Dresden, Germany — [2]PSI, Villigen, Switzerland — [3]KIT, Karlsruhe, Germany — [4]MPI CPfS, Dresden, Germany

$CeRh_2As_2$ hosts two superconducting (SC) phases tuned by magnetic field [1] and undergoes an additional transition at $T_0 = 0.55$ K (with $T_c = 0.35$ K) [2]. The nearly non-magnetic and strongly anisotropic nature of the T_0 phase suggests an itinerant quadrupolar order of the Ce moments [3]. Since Ce-4f electrons couple to the lattice, a lowering of the tetragonal symmetry at T_0 is anticipated.

To test this, we performed single-crystal X-ray diffraction in non-resonant mode and at the Ce L_3 edge to search for symmetry reduction and signatures of multipolar order. We examined a possible splitting of the high-q (552) Bragg reflections and conducted energy-dependent rocking-curve scans near the (π, π, 0) point.

These subtle effects were probed at ultralow temperatures using a high-brilliance SwissFEL beamline combined with a dilution refrigerator. The results are presented in this work.

[1] S. Khim et al., Science 373, 1012 (2021).

[2] K. Semeniuk et al., Phys. Rev. B 107, L220504 (2023).
[3] D. Hafner et al., Phys. Rev. X 12, 011023 (2022).

TT 62.7 Wed 15:00 P4

Pressure evolution of magnetic and electronic states in $CeAgSb_2$ — •Riley Mann, Oliver Busby, Christian de Podesta, Oliver Squires, and Malte Grosche — Cavendish Laboratory, University of Cambridge, Cambridge CB3 0US, United Kingdom

$CeAgSb_2$ is a Kondo lattice material which hosts a weak ferromagnetic ground state at ambient pressure. Through the application of pressure, ferromagnetism can be suppressed, suggesting a quantum critical point at a critical pressure $p_c \sim 34$kbar. Previous measurements have shown the emergence of new phases near this quantum critical region, two of which have been interpreted as antiferromagnetic, whereas the nature of the third phase remains unclear. Our quantum oscillation measurements at ambient pressure indicate strong quasiparticle mass enhancement, with effective masses up to 34 m_e.

We present preliminary high-pressure measurements in the vicinity of the quantum critical region and extending up to about 70 kbar. Resistivity, magnetic susceptibility, and radio-frequency tunnel diode oscillator measurements were performed in high pressure anvil cells to track phase transition signatures, clarify the structure of the high pressure phase diagram, and investigate non-Fermi liquid signatures in transport properties. Measurements at T<1K near p_c give insight into the order of the ferromagnetic transition near the critical point and into the nature of the unknown phase.

TT 62.8 Wed 15:00 P4

Electron-phonon coupling for impurity models with flat bands in the bath — •Max Fischer[1], Emin Moghadas[2], Niklas Witt[1], Alessandro Toschi[2], and Giorgio Sangiovanni[1] — [1]Institut für Theoretische Physik und Astrophysik and Würzburg-Dresden Cluster of Excellence ct.qmat, Universität Würzburg, 97074 Würzburg, Germany — [2]Institute of Solid State Physics, TU Wien, 1040 Vienna, Austria

In Anderson impurity models the hybridization is typically assumed to be constant close to the Fermi level. Extensions including local vibrations coupled to the impurity site have been extensively studied. In this respect, the impact of Holstein phonons on the Kondo effect is particularly interesting, due to the subtle interplay between the exchange coupling and the phonon dynamics. Retardation effects can become particularly relevant since in addition to the bare phonon frequency and the bare kinetic energy, the correlation-induced renormalized bandwidth enters into the game. We add yet another knob, which is the flatness of the fermionic bath and study with analytical, quantum Monte Carlo and renormalization group approaches the effect of a singularity in the hybridization function, following our previous study without phonons [1].
[1] M. Fischer, A.Poli, L. Crippa, D. Călugăru, S. Ciuchi, M. Vojta, A. Toschi, and G. Sangiovanni, arXiv:2503.14326 (2025).

TT 62.9 Wed 15:00 P4

The Fate of Kondo Correlations in Superconducting Magnetic Impurities beyond Mean Field — •Kilian Münz[1], Björn Kubala[1,2], Christian Ast[3], Joachim Ankerhold[1], and Ciprian Padurariu[1] — [1]Institute for Complex Quantum Systems and IQST, Ulm University, Ulm, Germany — [2]German Aerospace Center (DLR), Institute for Quantum Technologies, Ulm, Germany — [3]Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany

The interplay between strong electronic correlations (Kondo effect) and superconductivity is of fundamental interest in mesoscopic physics. We investigate the superconducting single-impurity Anderson model (SIAM) with Numerical Renormalization Group methods using the NRG Ljubljana code [1]. Calculations confirm the expected emergence of Yu-Shiba-Rusinov (YSR) states within the superconducting gap.

Simulations also yield the tails of the renormalized Kondo density of states extending above the gap. We demonstrate that these above-gap features translate directly into additional contributions in the tunneling current measured by scanning tunneling microscopy. Crucially, these Kondo-rooted spectral signatures exhibit a discontinuous change across the quantum phase transition of the superconducting SIAM. These NRG predictions show excellent qualitative agreement with recent experimental results from MPI-FKF Stuttgart.
[1] Žitko, Rok: NRG Ljubljana. DOI: 10.5281/ZENODO.4841076.

TT 62.10 Wed 15:00 P4

Using $1/N$ graph expansions to explore the mesoscopic regime of strongly correlated systems — •Andreas Schellenberger[1], Lidia Stocker[2], and Kai Phillip Schmidt[1] — [1]Friedrich-Alexander-Universität Erlangen-Nürnberg — [2]Max Planck Institute for the Physics of Complex Systems, Dresden

Finite-size effects in strongly correlated systems can generate nontrivial low-energy behavior in the mesoscopic regime, yet this regime is difficult to access with standard many-body techniques [1–3]. We present a novel graph-expansion method to systematically explore strongly correlated systems with one-to-all couplings. This approach enables controlled exploration of the corrections to the thermodynamic limit in terms of a $1/N$ expansion for light-matter systems or systems with collective bath modes.

We apply our approach to the open Kondo box model at zero temperature [4], where an Anderson impurity is coupled to a bath with finite level spacing. By computing energies, correlation functions, and entanglement measures, we investigate how the Kondo effect emerges as a function of the systems parameters, benchmarking our results against exact diagonalization and DMRG.
[1] K. Lenk, J. Li, P. Werner, M. Eckstein, arXiv:2205.05559 (2022)
[2] A. Kudlis, D. Novokreschenov, I. Iorsh, I. Tokatly, arXiv:2304.00805 (2023)
[3] P. Simon, I. Affleck, PRL 89.206602 (2002)
[4] C. Rössler et al., PRL 155.166603 (2015)

TT 62.11 Wed 15:00 P4

Low-dimensional critical behavior of correlated electrons, Mermin-Wagner theorem, and local self-energy — •Šimon Kos[1], Sunil D'Souza[1], Jan Gebel[1], Ján Minár[1], and Václav Janiš[2] — [1]University of West Bohemia, Univerzitní 8, CZ-301 00 Plzeň, Czech Republic — [2]Institute of Physics, The Czech Academy of Sciences, Na Slovance 2, CZ-182 00 Praha 8, Czech Republic

We present a theoretical treatment of low-dimensional critical behavior coming from electron correlations. The treatment is based on the Baym-Kadanoff approach, which involves one-particle self-consistency between the propagator and the self-energy, along with the bare two-particle interaction. In low dimensions, self-consistency prevents ordering in agreement with the Mermin-Wagner theorem and exhibits critical behavior as the temperature is lowered towards zero. The critical behavior enables the use of the polar approximation, which reduces the convolutive Schwinger-Dyson equation to an algebraic equation for the local propagator and self-energy, amenable to solution. We demonstrate the treatment using the example of a 1d Hubbard model with an attractive interaction, which describes the tendency toward superconductivity, in the FLEX approximation. We present various features of the algebraic Schwinger-Dyson equation and the quantities that enter it.

TT 62.12 Wed 15:00 P4

Emergent relativity and topology of interacting quadratic fermions — •Lukas Berger and Thomas C. Lang — Institute for Theoretical Physics, University of Innsbruck, Austria

We investigate the lattice realization of perfect quadratic band touching of fermions augmented by local Coulomb interactions via quantum Monte Carlo simulations. We show that due to the C_4 rotational symmetry of the lattice, interactions trigger an instability towards quantum anomalous Hall order. In contrast, once the rotational symmetry of the lattice is reduced to C_2, infinitesimally small interactions dynamically induce a topological transition from quadratic band touching to multiple Dirac cones before undergoing a Gross-Neveu transition where lattice symmetry is spontaneously broken via charge order. We directly monitor the separation of the Berry flux and the simultaneous emergence of Dirac-like excitation spectra.