TT 3 Correlated Electrons - Heavy Fermions

Zeit: Freitag 10:15–13:00 Raum: TU H3027

TT 3.1 Fr 10:15 TU H3027

Multiband Superconductivity in the heavy fermion $PrOs_4Sb_{12}$ — •Gabriel Seyfarth[1], Jean-Pascal Brison[1], Marie-Aude Méasson[2], Jacques Flouquet[2], Koichi Izawa[3], Y. Matsuda[3], H. Sugawara[4], and H. Sato[4] — [1]CRTBT-CNRS, 38042 Grenoble, France — [2]CEA-Grenoble, 38054 Grenoble, Fance — [3]ISSP, Chiba 277-8581, Japan — [4]Tokyo Metropolitan University, Tokyo 192-0397, Japan

In our contribution we show that several experimental measurements indicate that the superconducting phase of PrOs4Sb12 [1] involves quasiparticles of different effective masses and different gap amplitudes, i.e. it has a multiband character, like it is observed in the archetype of this class of superconductors, MgB2 [3]. These evidences come a) from Hc2(T) calculations (published in [5]) that reproduce the small positive curvature at low fields, assuming the existence of two different electronic bands, b) from Andreev-reflection measurements in Au-PrOs4Sb12 junctions and c) from the low field dependence of thermal transport measurements in the superconducting phase at very low temperatures (50mK). They are supported by dHvA measurements [6], which reveal a large spread of effective masses on the different sheets of the Fermi surface of this strongly correlated system. The discussion will include other experimental results which were interpreted in terms of unconventional superconductivity [2],[4].

References :

[1] E. D. Bauer (2002) Phys. Rev. B 65 100506 [2] E. Chia (2003) PRL 91 247003 [3] F. Giubileo (2001) PRL 87 177008 [4] K. Izawa (2003) PRL 90 117001 [5] M.-A. Measson (2004) Phys. Rev. B 70 064516 [6] H. Sugawara (2003) Acta Physica Polonica B 34 1125

TT 3.2 Fr 10:30 TU H3027

Competition between antiferromagnetism and superconductivity in $CeCu_2Si_2$ — •O. Stockert[1], E. Faulhaber[2], N. Stüsser[3], K. Prokes[3], W. Schmidt[4], G. Zwicknagl[5], H.S. Jeevan[1], M Deppe[1], M. Loewenhaupt[2], C. Geibel[1], and F. Steglich[1] — [1]Max-Planck-Institut für Chem. Physik fester Stoffe, D-01187 Dresden, Germany — [2]Institut für Festkörperphysik, TU Dresden, D-01062 Dresen, Germany — [3]Hahn-Meitner-Institut, D-14109 Berlin, Germany — [4]Institut Laue-Langevin, F-38042 Grenoble, France — [5]Institut für Math. Physik, TU Braunschweig, D-38106 Braunschweig, Germany

We report on neutron scattering experiments on magnetically ordered $CeCu_2Si_2$ single crystals exhibiting A- and A/S-phase anomalies. Below $T_N \approx 0.8\,K$ antiferromagnetic order has been detected with a propagation vector $\tau \approx$ (0.215 0.215 0.53) at $T = 50\,mK$. The magnetic order is due to nesting of the Fermi surface as indicated by renormalized band-structure calculations. The observation of incommensurate antiferromagnetic order as the nature of the A-phase in $CeCu_2Si_2$ suggests that a spin-density-wave instability is the origin of the quantum critical point in $CeCu_2Si_2$. Elastic high-resolution neutron scattering on both, A- and A/S-type crystals, reveal the long-range nature of the antiferromagnetic order in the A/S-crystal, but yield a considerable line broadening for the A-type crystal pointing to a finite domain size or correlation length. However, in energy scans no increased width of the magnetic peaks has been detected. Extensive measurements, performed on the A/S-crystal also in magnetic fields, show that in this crystal antiferromagnetism and superconductivity seem to exclude each other on a microscopic scale.

TT 3.3 Fr 10:45 TU H3027

Tunneling spectroscopy on epitaxial superconducting UNi_2Al_3 thin films — •Andrey Zakharov, Martin Jourdan, and Hermann Adrian — Johannes Gutenberg-Universität Mainz, Institut für Physik, Staudinger Weg 7, 55128 Mainz, Germany

Tunneling spectroscopy experiments on thin film planar junctions of the heavy-fermion superconductor UNi_2Al_3 were performed. Employing an in vacuo process it was possible to prepare cross-junctions with a*-axis oriented epitaxial thin films of UNi_2Al_3 as a base electrode, artificial insulating layer of AlO_x as a barrier and a well-known superconducting metal (Pb or In) as a counter electrode. The typical tunneling densities of states of the superconducting counter electrodes including strong coupling features were observed, proving the contacts to be in the tunneling regime with an essentially pin-hole free barrier. In the normal magnetically ordered state of the heavy-fermion compound a pseudogap was observed. First result of direct probing the superconducting density of states of UNi_2Al_3 are presented.

TT 3.4 Fr 11:00 TU H3027

Drude Response of Heavy Fermions in UNi_2Al_3 — •Marc Scheffler[1], Martin Dressel[1], Martin Jourdan[2], and Hermann Adrian[2] — [1]1. Physikalisches Institut, Universität Stuttgart, 70550 Stuttgart — [2]Institut für Physik, Universität Mainz, 55099 Mainz

The defining mass enhancement of the charge carriers in heavy-fermion compounds goes hand in hand with an equivalent decrease of the charge carrier relaxation rate. This relaxation rate can be identified from characteristics in the frequency-dependent conductivity: a roll-off in the real part $\sigma_1(\omega)$ and a maximum in the imaginary part $\sigma_2(\omega)$, two core predictions of the Drude model of metallic conduction.

Recently we succeeded with the first direct measurements of a Drude response in heavy-fermion UPd_2Al_3, revealing an extremely low relaxation rate in the GHz range. Now we present results on the related compound UNi_2Al_3 in the same frequency (45 MHz to 20 GHz) and temperature (1.65 K to 300 K) ranges. Again, at low temperatures we find a Drude behavior at GHz frequencies. Thus we can directly observe the relaxation rate as a function of temperature and use this to discuss the charge carrier density.

TT 3.5 Fr 11:15 TU H3027

Kondo-ion electron spin resonance of isotope clean $^{174}YbRh_2Si_2$ — •J. Wykhoff[1], J. Sichelschmidt[1], G. Knebel[2], G. Lapertot[2], J. Flouquet[2], J. Ferstl[1], H.-A. Krug von Nidda[3], C. Geibel[1], and F. Steglich[1] — [1]Max-Planck-Institut für Chemische Physik fester Stoffe, D-01187 Dresden, Germany — [2]Département de Recherche Fondamentale sur la Matière Condensée, SPSMS, CEA Grenoble, 38054 Grenoble, France — [3]Experimentalphysik V, Elektronische Korrelationen und Magnetismus, Institut für Physik, Universität Augsburg, 86135 Augsburg, Germany

The heavy-fermion compound $YbRh_2Si_2$ is located very close to a magnetic field induced quantum critical point. The unexpected observation of electron spin resonance (ESR) of the Kondo-ion Yb^{3+} *below* the Kondo temperature ($T_K \simeq 25$ K) might be a direct verification of the localized moment scenario of quantum criticality. We present the ESR of isotope clean $^{174}YbRh_2Si_2$ which was prepared at the CEA Grenoble. Its T behavior is very similar compared to that of $YbRh_2Si_2$. Especially, for the ESR linewidth an exponential behavior above $T \simeq 12$ K and a progressive reduction by decreasing T down to the lowest accessible $T = 1.7$ K could be confirmed in $^{174}YbRh_2Si_2$. However, $^{174}YbRh_2Si_2$ shows a smaller residual linewidth and a strongly reduced thermal line broadening in the whole T region. Assuming a smaller disorder in $^{174}YbRh_2Si_2$ these observations further support our previous finding that introducing disorder in $YbRh_2Si_2$ by La- or Ge-doping causes a more effective Yb^{3+} ESR relaxation. The question arises whether an ESR bottleneck effect could be responsible for the extremely narrow linewidth.

TT 3.6 Fr 11:30 TU H3027

Magnetic structure vs. crystallographic disorder in single crystalline UPt_2Si_2 — •S. Süllow[1], A. Otop[1], A. Loose[2], J. Klenke[2], R. Feyerherm[2], R.W.A. Hendrikx[3], and J.A. Mydosh[3,4] — [1]IFP, TU Braunschweig, Braunschweig, Germany — [2]BENSC, HMI, Berlin, Germany — [3]Leiden University, Leiden, The Netherlands — [4]MPI-CPfS, Dresden, Germany

We present a detailed investigation of the crystallographic structure, lattice disorder and magnetic order of a single–crystal of the moderately mass–enhanced U intermetallic UPt_2Si_2. Utilizing the bright contrast between U, Pt and Si in neutron scattering, we establish the lattice symmetry to be $P4/nmm$ ($CaBe_2Ge_2$-lattice). Moreover, the observation of an anomalously large thermal displacement factor U_{11}/U_{22} for the Pt(2) and Si(2) sites at low temperatures indicates frozen–in disorder on these sites. The material undergoes an antiferromagnetic transition below $T_N = 32.1\,K$, with ferromagnetically coupled a–b–planes and an antiferromagnetic stacking along the c axis. In addition, as result of the crystallographic disorder we observe magnetic clusters up to $T_{irr} = 34\,K$. The existence of the clusters explains the previously observed anomalous antiferromagnetic domain pinning in the compound [1]. Moreover, the disorder bears relevance to the electronic transport properties of the compound, which are commonly metallic along the a axis, but disorder

dominated in c direction.

[1] A. Otop *et al.*, J. Appl. Phys. 95 (2004) 6702

TT 3.7 Fr 11:45 TU H3027

Magnetic field-induced non-Fermi-liquid resistivity in YbAgGe single crystals — •Philipp G. Niklowitz[1], Georg Knebel[1], Sergey L. Budko[2], Paul C. Canfield[2], and Jacques Flouquet[1] — [1]SPSMS/CEA-Grenoble, 17 rue des Martyrs, 38054 Grenoble cedex 9, France — [2]Ames Laboratory, Iowa State University, Ames, Iowa 50011, USA

Hexagonal YbAgGe has recently been recognised as a new heavy-fermion (HF) system with $T_K = 24$ K, γ of a few hundred mJ/molK^2 and planar magnetic anisotropy $\chi_{ab}/\chi_c \approx 3$ at low temperatures. Two magnetic transitions below 1 K can be fully suppressed with fields $H < 10$ T. In going from low to higher H and T, the $H-T$ phase diagram down to 0.4 K shows a first-order transition from an antiferromagnetically ordered phase to a second magnetically ordered phase and then a second-order phase transition to a paramagnetic (field-polarised) phase. We have investigated YbAgGe for the first time down to 50 mK by measuring the resistivity ρ of single crystals in fields up to 14 T. Our results extend the $H-T$ phase diagram to the lowest temperatures for $H \perp c$ and $H \parallel c$. Whereas at low H, $\rho(T)$ reveals a temperature exponent $n \geq 2$, close to and beyond the critical field of the second-order phase transition we find $1 < n < 1.5$ and strong enhancement of the temperature dependence of $\rho(T)$, before Fermi-liquid behaviour is recovered above 10 T. Particularities in the appearance of the unconventional form of $\rho(T)$ will be discussed considering the HF nature and structural aspects of YbAgGe. YbAgGe appears to be one of few Yb-based stoichiometric systems, where quantum-critical behaviour may be induced by a magnetic field.

TT 3.8 Fr 12:00 TU H3027

Optical spectroscopy of the mixed valence semiconductor TmSe — •Michael Dumm[1], Boris Gorshunov[1], Daniel Faltermeier[1], Philipp Haas[1], Martin Dressel[1], and Takeshi Matsumura[2] — [1]1. Physikalisches Institut, Universität Stuttgart, 70550 Stuttgart — [2]Physics Department, Tohoku University, Sendai 980-77, Japan

Among mixed-valence compounds TmSe has attracted particular interest because of its unusual physical properties. For instance, beyond unique magnetic properties this semiconductor shows no signs of activated behavior in the temperature dependence of the dc conductivity. We investigated the dynamical conductivity of TmSe at 5 K $\leq T \leq$ 300 K by employing infrared and quasi-optical Terahertz techniques in a broad frequency range 10 cm$^{-1} \leq \nu \leq$ 10000 cm^{-1} covering all relevant energy scales. At high temperatures, the optical spectra reveal signatures of a two-component free-carrier response originating on the one hand from light d-electrons and on the other hand from heavy f-electronic states hybridized with the charge carriers in the conduction band. Going towards lower temperatures, the heavy carrier response starts diminishing and a gap-like feature builds up below 100 cm^{-1}. On the basis of a detailed analysis of our optical and dc data, we will discuss the origin of the gap. Furthermore, we will compare the results obtained on TmSe to those measured on other Kondo insulators like YbB_{12} and SmB_6.

TT 3.9 Fr 12:15 TU H3027

Geometrical Frustration in Rare-Earth Face-Centered Cubic Crystals — •Veronika Fritsch, Joe D. Thompson, and John L. Sarrao — Los Alamos National Laboratory, Los Alamos, New Mexico 87544, USA

In a 3-dimensional solid the simplest form of magnetic frustration is spins on a tetrahedron with antiferromagnetic coupling. A face-centered cubic (fcc) lattice is a simple example of a network of edge-sharing tetrahedra; however, most fcc compounds exhibit well-defined magnetic order, dominated by next-neighbor (nn) and next-nearest-neighbor (nnn) interactions. To minimize the effects of nnn interactions and maximize frustration, the network of edge-sharing tetrahedra has to be divided into sub-networks of corner-sharing tetrahedra, as is realized in pyrochlore and spinel structures. A further example of a fcc-lattice split in two sub-networks of corner-sharing tetrahedra are the intermetallic ternaries $RE\mathrm{InCu_4}$ (RE = heavy rare-earth). Here the rare-earth ions occupy a fcc-lattice, where half of the tetrahedra are filled with an In-ions and the other half with a Cu-tetrahedron. The extent of frustration in these systems is determined by the magnetic moment of the rare-earth ion and second by their separation distance, which can be tuned with chemical substitution, e.g. Ni for Cu. We present measurements of electrical resistivity, magnetic susceptibility and specific heat on single crystals of the title compounds with the trivalent rare-earth ions Gd, Dy, Ho and Er, demonstrating geometrical frustration of their spin and orbital angular momentum.

TT 3.10 Fr 12:30 TU H3027

Kondo-lattice type models at finite temperatures with exact diagonalzation — •Ivica Zerec, Burkhard Schmidt, and Peter Thalmeier — Max-Planck-Institut für Chemische Physik fester Stoffe, Nöthnitzer Str. 40, 01187 Dresden

The competition between the RKKY interaction and the Kondo screening in heavy fermion compounds is considered to be the origin of quantum critical phase transitions. They are generically described by the Doniach phase diagram, which was originally obtained from a simplified version of the Kondo lattice model in one dimension - the Kondo necklace model. We consider a similar model for the 2D systems, derived from the Kondo lattice model neglecting charge degrees of freedom. We use the finite temperature Lanczos method to numerically diagonalize the Hamiltonian matrix for finite clusters and calculate thermodynamic and correlation functions for various values of the coupling constants and the external magnetic field. The results are used to construct the phase diagrams for the finite clusters. These may provide some insight into the physics in the neighborhood of a quantum critical point.

TT 3.11 Fr 12:45 TU H3027

Fluctuation conductivity of thin films and nanowires near a parallel-field-tuned superconducting quantum phase transition — •Nayana Shah[1], Andrei Lopatin[2], and Valerii Vinokur[2] — [1]Institut für Theoretische Physik, Universität zu Köln, 50937 Köln, Germany — [2]Materials Science Division, Argonne National Laboratory, Argonne, Illinois 60439, USA

We calculate the fluctuation correction to the normal state conductivity in the vicinity of a quantum phase transition from a superconducting to normal state, induced by applying a magnetic field parallel to a dirty thin film or a nanowire with thickness smaller than the superconducting coherence length. We find that at zero temperature, where the correction comes purely from quantum fluctuations, the positive Aslamazov-Larkin contribution, the negative density of states contribution, and the Maki-Thompson interference contribution, are all of the same order and the total correction is negative. Further we show that based on how the quantum critical point is approached, there are three regimes that show different temperature and field dependencies which should be experimentally accessible.