TT 54: Correlated Electrons: Heavy Fermions

Time: Wednesday 9:30–11:00 Location: HSZ 204

TT 54.1 Wed 9:30 HSZ 204

Charge fluctuations in SmB_6 — •Chul-hee Min[1,2], Peter Lutz[1,2], Sebastian Fiedler[1,2], Boyoun Kang[3], Beongki Cho[3], Hyung-do Kim[4], Hendrik Bentmann[1,2], and Friedrich Reinert[1,2] — [1]Universität Würzburg, Experimentelle Physik VII & Röntgen Research Center for Complex Material Systems, 97074 Würzburg, Germany. — [2]Karlsruhe Institut für Technologie, Gemeinschaftslabor für Nanoanalytik, 76021 Karlsruhe, Germany. — [3]School of Materials Science and Engineering, Gwangju Institute of Science and Technology, Gwangju 500-712, Korea. — [4]Department of Physics and Astronomy, Center for Correlated Electron Systems, Institute for Basic Science, Seoul National University, Seoul 151-747, Republic of Korea.

Kondo insulators can have nontrivial Z_2 topology because their energy gap opens at the Fermi energy (E_F) by the hybridization between an odd parity- renormalized f band and an even parity- conduction d band. Samarium hexaboride (SmB_6) is a promising candidate for the realization of such a correlated topological insulator. Here, we present the electronic structure of SmB_6 by angle-resolved photoemission spectroscopy. Our spectra reveal that the bottom of the odd parity- d-f hybridized band at the X point gradually shifts from below to above E_F with decreasing temperature. Moreover, by comparison with theoretical calculations, the signatures of nontrivial surface states are observed. Our results indicate that charge fluctuations play a major role during the gap evolution, and can be important in determining its Z_2 topological indices.

TT 54.2 Wed 9:45 HSZ 204

Intense ferromagnetic fluctuations in the heavy-fermion antiferromagnet CeB_6 — •D. Inosov[1,2], H. Jang[2], G. Friemel[2], J. Ollivier[4], A. V. Dukhnenko[3], N. Yu. Shitsevalova[3], V. B. Filipov[3], and B. Keimer[2] — [1]Inst. für Festkörperphysik, TU Dresden, Germany. — [2]MPI für Festkörperforschung, Stuttgart, Germany. — [3]Inst. for Problems of Material Sciences, Kiev, Ukraine. — [4]Inst. Laue-Langevin, Grenoble, France.

Heavy-fermion metals exhibit a plethora of low-temperature ordering phenomena, among them the so-called hidden-order phases that in contrast to conventional magnetic order are invisible to standard neutron diffraction. One of the oldest and structurally simplest hidden-order compounds, CeB_6, is famous for an elusive phase attributed to the antiferroquadrupolar ordering of Ce 4f moments. In its ground state, CeB_6 also develops a more usual antiferromagnetic (AFM) order. Hence, its essential low-temperature physics was always considered to be governed by AFM interactions between the dipolar and multipolar Ce moments. Our recent inelastic neutron scattering experiments overturned this established perspective by uncovering an intense ferromagnetic (FM) low-energy collective mode that dominates the magnetic excitation spectrum of CeB_6, thus placing CeB_6 much closer to a FM instability than could be anticipated. This propensity of CeB_6 to ferromagnetism may account for much of its unexplained behavior, such as the existence of a pronounced electron spin resonance, and should lead to a substantial revision of existing theories that have so far largely neglected the role of FM interactions.

TT 54.3 Wed 10:00 HSZ 204

Surface Properties of Rare Earth Hexaborides Studied by X-Ray Spectroscopy — •Nadine Heming[1], Uwe Treske[1], Dmytro S. Inosov[2,3], Martin Knupfer[1], Bernd Büchner[1], Natalya Yu. Shitsevalova[4], Volodymyr B. Filipov[4], Emile Rienks[5], and Andreas Koitzsch[1] — [1]IFW Dresden — [2]TU Dresden — [3]MPI Stuttgart — [4]Frantsevich Inst. Kiev — [5]HZB, Berlin

Rare earth hexaborides (RB_6) are a group of materials that have unique crystal structures but a striking variety of physical properties. SmB_6, for example, is a mixed valence heavy fermion compound and well known for its anomalous low temperature resistivity behavior. Transport experiments have evidenced, that its unusual residual conductivity occurs only at the surface, making this compound the prime candidate for the proposed new material class of "Topological Kondo Insulators". However, it is known for decades that the surface undergoes valence changes and reconstructions, which may influence the properties of the material and could even form the basis of alternative scenarios. Here we use x-ray spectroscopy (XPS, XAS) to explicitly study surface properties of SmB_6 and CeB_6. The heavy fermion compound CeB_6 is known for many years for its unusual magnetic properties at low temperatures, in particular the elusive antiferroquadrupolar ordering at $T_Q = 3.2\,K$. To study its electronic structure surface sensitive techniques such as ARPES and STM are in order, which benefit from deeper knowledge of the surface properties as well.

TT 54.4 Wed 10:15 HSZ 204

Magnetic phases in the heavy-fermion system $Yb(Rh_{1-x}Co_x)_2Si_2$ — •A. Hannaske[1], O. Stockert[1], C. Klingner[1], N. Mufti[1], C. Krellner[2], A. Hoser[3], J.-U. Hoffmann[3], S. Matas[3], S. Capelli[4], M.-H. Lemee-Cailleau[4], K. Kaneko[5], M. Brando[1], C. Geibel[1], and F. Steglich[1] — [1]Max-Planck-Institut CPfS, Dresden, Germany — [2]Goethe-Universität Frankfurt, Frankfurt a. M., Germany — [3]Helmholtz-Zentrum Berlin, Berlin, Germany — [4]Institut Laue-Langevin, Grenoble, France — [5]Japan Atomic Energy Agency, Tokai, Japan

One route to get insight into the unusual magnetic properties of quantum critical $YbRh_2Si_2$ is to study magnetism in the alloying series $Yb(Rh_{1-x}Co_x)_2Si_2$. Isoelectronic doping of Co on the Rh site leads to a stabilization of the magnetic order. The magnetic phases in $Yb(Rh_{1-x}Co_x)_2Si_2$ have been investigated in detail by thermodynamic measurements and neutron scattering. In pure $YbCo_2Si_2$ the occurrence of antiferromagnetic domains plays an important role in understanding the magnetic $B-T$ phase diagram. While for $Yb(Rh_{1-x}Co_x)_2Si_2$ with high Co content our measurements clearly reveal an incommensurate magnetically ordered phase below T_N followed by a commensurate phase at low T, the magnetic order drastically changes below about $x \approx 0.58$ where surprisingly ferromagnetic behavior was observed. We will discuss this finding and its impact on the quantum criticality in $YbRh_2Si_2$.

TT 54.5 Wed 10:30 HSZ 204

Valence determination in $CeMIn_5$ (M=Co, Rh, and Ir) and CeT_2Al_{10} (T=Fe, Rh, and Os) using HAXPES — •M. Sundermann[1], F. Strigari[1], M.W. Haverkort[2], Y. Muro[3], T. Takabatake[3], E.D. Bauer[4], J.D. Thompson[4], Y.F. Liao[5], K.-D. Tsuei[5], L.H. Tjeng[2], and A. Severing[1] — [1]University of Cologne, Institute of Physics II, 50937 Cologne, Germany — [2]Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany — [3]Department of Quantum Matter, AdSM, Hiroshima University, Higashi-Hiroshima 739-8530, Japan — [4]Los Alamos National Laboratory, Los Alamos, New Mexico, USA — [5]National Synchrotron Radiation Research Center, Hsinchu 30076, Taiwan

The hybridization of $4f$ electrons and the conduction band (cf-hybridization) is an important ingredient for the versatile physics of Ce compounds. In the $CeMIn_5$ superconductivity appears in the vicinity of a quantum critical point where the $4f$ moments are magnetically ordered on one side and more itinerant due to the stronger cf-hybridization on the other. In the antiferromagnetic Ce Kondo semiconductors CeT_2Al_{10} the ordered moments are *not* aligned along the easy axis and they have unusually high ordering temperatures. There are speculations that the cf-hybridization has an impact on the magnetic ordering. — We performed the bulk sensitive hard x-ray photoemission spectroscopy (HAXPES) for $CeMIn_5$ and CeT_2Al_{10} and obtained the occupancy of the $4f$ states and important parameters like the cf hybridization by analyzing the data within an Anderson impurity Ansatz which contains the full multiplet theory.

TT 54.6 Wed 10:45 HSZ 204

XMCD-Signatures of Kondo and Heavy Fermion Behaviour in the Surface Intermetallic $CePt_5$/Pt(111) — Christian Praetorius, •Martin Zinner, and Kai Fauth — Physikalisches Institut, Universität Würzburg, Am Hubland, D-97074 Würzburg

In this contribution, we explore the detection of magnetic signatures of Kondo and heavy fermion physics by x-ray spectroscopy and study the anisotropic paramagnetic Ce-$4f$ response in $CePt_5$, prepared on Pt(111). Qualitatively, the magnetic behaviour above $T \gtrsim 20$ K is readily understood in terms of a hexagonal crystal field (CF), acting on weakly interacting, considerably screened Ce-$4f$ moments. A quantitative description necessitates distinct CF parameters for 'inner' and 'surface' atomic layers. This approach is strongly supported by complementary structural information (LEED-IV). Treating both CF and

Kondo physics within a simplified NCA approach [1] proved unsuccessful and we therefore resort to a more ad-hoc kind of Hamiltonian.

The paramagnetic response displays an anomaly ($T^* \approx 18$ K), which we shall discuss as signalling the transition towards the coherent heavy fermion state . Well below T^* we find Ce $4f$ saturation moments much smaller than the free ion values. Their occurrence, too, can be understood to be characteristic of the coherent state and associated with a Lifshitz transition as predicted theoretically [2]. X-ray spectroscopy thus proves valuable for investigating strongly correlated electron systems in case sufficiently well-defined surfaces can be obtained.

[1] G. Zwicknagl, V. Zevin und P. Fulde, *Z. Phys. B* **79**, 365 (1990)
[2] K. S. D. Beach and F. F. Assaad, *Phys. Rev. B* **77**, 205123 (2008)