O 50: Symposium: Surface Spectroscopy on Kondo Systems II (Invited Speakers: Jonathan Denlinger, Johann Kroha, Alexander Schneider)

Time: Wednesday 15:15–18:00 Location: HE 101

Invited Talk O 50.1 Wed 15:15 HE 101

ARPES Mapping of the Fermi Surfaces of Three-Dimensional Heavy Fermion Systems — •Jonathan Denlinger — Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA

Angle-resolved photoemission (ARPES) on most heavy fermion f-electron systems is a very challenging task because they are typically three-dimensional, incurring effects of k_z-broadening, and may not cleave well. Also their electronic structures typically contain many overlapping bands and very small (meV) hybridization energy scales near the Fermi level thus requiring high momentum- and energy-resolution. Experimental advances in electron spectrometers, x-ray synchrotron sources and automation have enabled acquisition of large variable photon-energy ARPES electronic structure maps that permit a k_z-tomographic determination of the 3D band structures and Fermi surfaces with sufficient detail to be truly complementary to dHvA in addressing theoretical predictions for this class of materials. Progress in this direction is discussed for the systems of $CeRu_2Si_2$, $CeCoIn_5$ and YbBiPt.

Invited Talk O 50.2 Wed 15:45 HE 101

Local Kondo Physics vs. Lattice Effects in Real Solids — •Johann Kroha — Physikalisches Institut, Universität Bonn

In recent years, photoemission spectroscopy (PES) as well as scanning tunneling microscopy (STM) have been developed into powerful tools for investigating the low-energy features characteristic for strongly correlated impurity and lattice systems due to their high spectral resolution of only a few meV.

We first review briefly the physical origin of the multiple low-energy resonances in heavy-electron compounds as Kondo spin fluctuations, involving the crystal-field or spin-orbit split 4f orbitals of rare earth ions. We then discuss the different shape of STM Kondo spectra, where multiple Kondo resonances are not observed, and explain this fact by the orbital selectivity of the STM in contrast to PES. We propose a method to determine the spatial orientation of individal orbitals of Kondo impurities on a metal surface from their STM spectra.

In the second part of the talk we analyze theoretically recent PES experiments on the heavy fermion compound $CeCu_{6-x}Au_x$, which undergoes a quantum phase transition (QPT) to an antiferromagnetically ordered state at $x \simeq 0.1$. The PES spectra, taken at $T \simeq 10$ K, i.e. well above the ordering temperature, probe the local Kondo physics of the Ce atoms, and indicate a sharp drop of the Kondo temperature T_K near $x = 0.1$. By analyzing the origin of this drop theoretically, we conjecture on whether in $CeCu_{6-x}Au_x$ the Hertz-Millis scenario (persistence of quasiparticles through the QPT) or the local quantum critical scenario (breakdown of quasiparticles at the QPT) is realized.

Invited Talk O 50.3 Wed 16:15 HE 101

Local Correlation Physics of Transition Metal Atoms on Noble Metal Surfaces — •M. Alexander Schneider — Lehrstuhl für Festkörperphysik, Universität Erlangen, Staudtstr. 7, D-91058 Erlangen

Scanning tunneling spectroscopy at low temperatures has allowed experimentalists to access the properties of the single Kondo impurity at surfaces [1]. This local approach proved fruitful as it has opened the route to study systematically the coupling of an impurity to various electronic states at the surface [2] and also the coupling between Kondo impurities [3]. In my talk I will discuss the experimental findings of the properties of Co-Atoms on noble metal surfaces and multilayer substrates.

[1] J. Li, et al., Phys. Rev. Lett **80**, 2893 (1998) and V. Madhavan, et al., Science **280**, 567 (1998)

[2] M.A. Schneider, et al., Jap. J. Appl. Phys. **44 (7B)**, 5328 (2005)

[3] P. Wahl, et al., Phys. Rev. Lett. **98**, 056601 (2007)

O 50.4 Wed 16:45 HE 101

Kondo Peak Splitting in a Magnetic Field for Ti/CuN/Cu(100)-$c(2 \times 2)$ — •Harald Brune[1,2], Markus Ternes[1], Christopher P. Lutz[1], Cyrus F. Hirjibehedin[1,3], and Andreas J. Heinrich[1] — [1]IBM Almaden Research Center — [2]Ecole Polytechnique Fédérale de Lausanne — [3]London Centre for Nanotechnology

dI/dV–spectra recorded with an STM operating at 0.6 K show a Kondo peak when the tip is centered over individual Ti atoms adsorbed onto the Cu sites of CuN-$c(2\times2)$–islands on a Cu(100) surface. In the gas phase Ti has $S = 1$, however, the observed spectra are suggestive of $S = 1/2$. The peak is sufficiently narrow to observe its splitting under an out-of-plane magnetic field. We discuss the results in light of measurements of the d-state LDOS centered at 0.7 eV above E_F.

O 50.5 Wed 17:00 HE 101

Contribution of the surface state to the observation of the surface Kondo resonance — •Jörg Henzl and Karina Morgenstern — Insitut für Festkörperphysik, Leibniz Universität Hannover, Germany

Tunneling spectra obtained on and near Co atoms adsorbed on Ag(111) show at 5 to 6 K a Kondo resonance that appears as a characteristic dip around the Fermi energy. The feature is present up to 1.5 nm around Co atoms adsorbed on terraces with the surface state onset in the occupied region of the density of states. On a narrow terrace, where the surface state onset lies in the unoccupied region of the density of states, it is only present up to 0.5 nm. This difference demonstrates directly the importance of the surface state electrons in the observation of the surface Kondo resonance.

O 50.6 Wed 17:15 HE 101

Kondo effect of subsurface Fe and Co impurities in Cu(100) - a comparative STS study — •Alexander Weismann, Martin Wenderoth, Henning Prüser, and Rainer G. Ulbrich — IV. Physikalisches Institut; Georg-August Universität Göttingen, Germany

We prepared single isolated subsurface iron and cobalt atoms beneath the Cu(100) surface by co-deposition of host metal and impurity compound under UHV conditions. The STM topographies at 6K show bulk state LDOS oscillations with four-fold symmetry in the vicinity of the defects. The observed patterns are in good agreement with the results of calculations based on host metals Greens function. This allows a depth classification and an extraction of the Kondo-related scattering phase from the STM experiment. In STS measurements both species of impurities show characteristic Kondo features on distinctly different energy scales. The dI/dV spectra show Fano line shapes depending on depth of the impurity below the surface. In the case of Fe the observed resonance width is extremely narrow so that even in the topographies a significant change of the interference pattern within +/- 3mV around zero bias can be observed. This work was supported by DFG SFB 602 TPA3.

O 50.7 Wed 17:30 HE 101

Electronic structure of thin ytterbium layers on W(110) — •Yury Dedkov[1], Denis Vyalikh[1], Matthias Holder[1], Martin Weser[1], Serguei Molodtsov[1], Yury Kucherenko[2], Mikhail Fonin[3], and Clemens Laubschat[1] — [1]Institut für Festkörperphysik, TU Dresden, Germany — [2]Institute for Metal Physics, Kiev, Ukraine — [3]Fachbereich Physik, Universität Konstanz, Germany

Among the lanthanides, Yb and Ce are of fundamental interest, because of the strong interaction between $4f$ and valence-band (VB) states leading to mixed-valence and Kondo phenomena in a number of compounds [1,2]. This analogy between Yb and Ce systems has been explained on the basis of the electron-hole symmetry of the quasiatomic $4f$ shell. While the correspondence has been established for a number of compounds, no evidence for such symmetry has been reported up to now for the pure metals. Motivated by the recent work [3], we report on the results of the angle-resolved photoemission (PE) studies of thin layers of Yb (1-3 ML-thick) on W(110) surface. The clear splitting of the Yb $4f_{7/2}$ state was observed in the PE spectra measured around $\overline{\Gamma}$ point for 1 ML-thick Yb film. The measured PE spectra were analyzed by means of the simplified periodic Anderson model.

[1] C. Laubschat, G. Kaindl, W.-D. Schneider, B. Reihl, and N. Mårtensson, Phys. Rev. B **33**, 6675 (1986).

[2] F. Patthey, J.-M. Imer, W.-D. Schneider, H. Beck, Y. Baer, and B. Delley, Phys. Rev. B **42**, 8864 (1990).

[3] D. V. Vyalikh, Yu. Kucherenko, S. Danzebächer, Yu. S. Dedkov, C. Laubschat, and S. L. Molodtsov, Phys. Rev. Lett. **96**, 026404 (2006).

O 50.8 Wed 17:45 HE 101

Conductance and Kondo effect of a controlled single atom contact — •NÉEL NICOLAS, KRÖGER JÖRG, LIMOT LAURENT, and BERNDT RICHARD — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Germany

The tip of a low-temperature scanning tunneling microscope is brought into contact with individual cobalt atoms adsorbed on Cu(100). A smooth transition from the tunneling regime to contact occurs at a conductance G around the quantun of conductance G0. Spectroscopy in the contact regime, i. ,e., at currents in a micro-ampere range was achieved and indicated a significant change of the Kondo temperature TK. Calculations indicate that the proximity of the tip shifts the cobalt d-band and thus affects TK.