

TT 35 Correlated Electrons - Quantum Critical Phenomena

Zeit: Mittwoch 11:15–13:00

Raum: TU H104

TT 35.1 Mi 11:15 TU H104

Evidence for a ferromagnetic quantum critical point in CePd_{1-x}Rh_x — ●CHRISTOPH GEIBEL¹, JULIAN SERENI², ROBERT KÜCHLER¹, and TEODORA RADU¹ — ¹MPI für Chemische Physik fester Stoffe, D-01187 Dresden, Germany — ²Centro Atomica Bariloche-CNEA, 8400 S.C. de Bariloche, Argentina

The behavior at the disappearance of magnetic order in Ce-based systems is presently a subject of strong interest. While there exist many Ce-based compounds showing an antiferromagnetic critical point, appropriate candidates for the study of the disappearance of a ferromagnetic (F) state are very scarce. Theories presently favor a first order critical point in pure systems, while disorder is suspected to lead to a continuous second order quantum critical point. One attractive candidate is the alloy CePd_{1-x}Rh_x reported to evolve from an F - Ce³⁺ state at $x = 0$ to a non-magnetic, valence fluctuating state at $x = 1$. However, the disappearance of its F state has never been thoroughly investigated. We report here a detailed investigation of this system by means of ac-susceptibility (χ_{ac}), specific heat (C_p) and thermal expansion (β) measurements. Our results indicate a continuous disappearance of the F-state, with $T_c \rightarrow 0$ K at around $x_c r \approx 0.85$ as traced following the sharp $\chi_{ac}(T)$ maximum. In the vicinity of the quantum critical point at $x_c r$, power law behavior is observed in $C_p(T)$ and in $\beta(T)$. These results shall be discussed in the context of present theories

TT 35.2 Mi 11:30 TU H104

Ferromagnetic Quantum Phase Transition of Single Crystalline CeSi_{1.81} under High Pressure — ●SANDRA DROTZIGER¹, CHRISTIAN PFLEIDERER^{1,2}, MARC UHLARZ¹, HILBERT V. LÖHNEYSSEN^{1,2}, DMITRI SOUPTTEL³, WOLFGANG LÖSER³, and GÜNTER BEHR³ — ¹Physikalisches Institut, Universität Karlsruhe, D-76128 Karlsruhe, Germany — ²Forschungszentrum Karlsruhe, Institut für Festkörperphysik, D-76021 Karlsruhe, Germany — ³Leibniz-Institut für Festkörper- und Werkstofforschung Dresden, PF 27 01 16, D-01171 Dresden, Germany

The rare-earth system CeSi_x develops ferromagnetic order at low temperatures for $1.50 < x < 1.85$. With decreasing Si concentration a structural phase transition between a α -ThSi₂ and a α -GdSi₂ structure occurs. We report the pressure dependence of the magnetisation of single crystalline CeSi_{1.81} for magnetic fields parallel to the crystallographic a -axis, being an easy magnetic direction. Our samples belong to a new generation of CeSi_x single crystals, in which the structural phase transition is observed at $x = 1.85$. With increasing pressure the ordered magnetic moment μ_S and the Curie temperature T_C disappear continuously above a critical pressure $p_c \approx 13 \pm 0.2$ kbar. This behavior is consistent with the existence of a ferromagnetic quantum critical point at p_c . In contrast to the existence of a quantum critical point, magnetic isotherms $M(B)$ do not show clear evidence of a divergence of the uniform susceptibility at p_c . The possible origin of these inconsistencies will be discussed.

TT 35.3 Mi 11:45 TU H104

Quantum Critical Behavior in Yb_{1-x}La_xRh₂Si₂ Studied by Low Temperature Resistivity in Magnetic Fields and under High Pressure — ●MICHAEL NICKLAS, JULIA FERSTEL, CHRISTOPH GEIBEL, and FRANK STEGLICH — Max-Planck-Institute for Chemical Physics of Solids, Nöthnitzer Str.40, 01187 Dresden

The stoichiometric heavy fermion system YbRh₂Si₂ is situated close to a quantum critical point (QCP). At zero magnetic field very weak antiferromagnetic order occurs at $T_N = 70$ mK. Substitution of Si by larger Ge reduces T_N , however, difficulties in sample preparation prevent a complete suppression of T_N by Ge-doping. An alternative route to suppress the antiferromagnetic order is the partial substitution of Yb by larger La in Yb_{1-x}La_xRh₂Si₂.

We present pressure studies of the electrical resistivity of the paramagnetic 5% and 10% La substituted Yb_{1-x}La_xRh₂Si₂. Applying pressure reduces the unit cell volume again and the system can be tuned through the critical volume. However, substitution of the magnetic ion by non-magnetic La at the Yb-site has more subtle effects and acts not just as chemical pressure on the system.

TT 35.4 Mi 12:00 TU H104

Magnetization dynamics of YbIr₂Si₂ — ●ARNO HIESS¹, OLIVER STOCKERT², MICHAEL M. KOZA¹, ZAKIR HOSSAIN³, and CHRISTOPH GEIBEL² — ¹ILL, Grenoble, France — ²MPI-CPFS, Dresden, Germany — ³IIT, Kanpur, India

Several intermetallic compounds containing cerium, ytterbium or uranium exhibit deviation from Landau-Fermi-liquid behaviour when tuned through a magnetic instability by means of a control parameter such as doping, hydrostatic pressure or magnetic fields. Within this class of compounds YbIr₂Si₂ occupies a special place as it exists in two crystallographic modifications: one (P-type) showing antiferromagnetic order below 0.7 K, the other (I-type) remains paramagnetic down to lowest temperatures. We here report on inelastic neutron scattering experiments investigating the magnetization dynamics in the paramagnetic state of both modifications. Magnetic scattering has been identified for energy transfers smaller 40 meV. Surprisingly, only the I-type modification shows two well-resolved crystal-field transitions whereas for the magnetically ordered P-type modification a broad (most-probable quasi-elastic) signal is observed. We discuss these observations in terms of the crystallographic local ytterbium site symmetry as well as in respect to their unusual thermodynamic (electronic) properties.

TT 35.5 Mi 12:15 TU H104

Field-tuned Quantum Critical Point in Antiferromagnetic Metals — ●INGA FISCHER and ACHIM ROSCH — Institut für theoretische Physik, Universität zu Köln

A magnetic field applied to an antiferromagnetic metal can destroy the long-range order and thereby induce a quantum critical point. Such field induced quantum critical behaviour is the focus of many recent experiments. We investigate theoretically the quantum critical behavior of clean antiferromagnetic metals subject to a static, spatially uniform, external magnetic field. The external field is not only a means for tuning the control parameter, it also influences the dynamics of the order parameter by inducing spin precession. This is described by an exactly marginal operator in the spin-fluctuation theory put forward by Hertz. We investigate how the interplay of precession and damping determines the correlation length, specific heat, magnetocaloric effect, and scattering rate. While critical exponents remain the same, the universal scaling functions are modified and even the sign of leading corrections e.g. to the specific heat can be changed.

TT 35.6 Mi 12:30 TU H104

NRG Study of the Quantum Critical Properties of the Sub-Ohmic Spin-Boson Model — ●NINGHUA TONG¹, MATTHIAS VOJTA¹, and RALF BULLA² — ¹Institute for Theory of Condensed Matter, University of Karlsruhe — ²Theoretical Physics III, Institute for Physics, University of Augsburg

Using the bosonic numerical renormalization group technique, we study the quantum critical properties of the sub-Ohmic spin-boson model. This model describes a two-level system imbedded in a bosonic bath with power-law spectrum density $J(\omega) \sim \omega^s$. In the sub-Ohmic regime $0 < s < 1$, there exists a line of quantum critical points separating localized and delocalized phases. The critical exponents are calculated and the hyperscaling relations are found to be fulfilled in the range $0 < s < 1$. In small s limit, these results agree well with the perturbative RG calculation, but contradict the existing results for the corresponding long-range Ising model. We conclude that the naive quantum-classical mapping fails for the spin-boson model in the regime $0 < s < 1/2$.

TT 35.7 Mi 12:45 TU H104

Fermi surface symmetry breaking on a square lattice — ●HIROYUKI YAMASE¹, VADIM OGANESYAN², and WALTER METZNER¹ — ¹Max-Planck-Institute for Solid State Research, Heisenbergstrasse 1, D-70569, Stuttgart, Germany — ²Department of Physics, Princeton University, Princeton, NJ 08544, USA

We analyze a mean-field model of electrons with pure forward scattering interactions on a square lattice, which exhibits spontaneous Fermi surface symmetry breaking with a d -wave order parameter. As a function of chemical potential, the phase transition is typically first order at low temperature (T) and second order at high T . It is, however, found that Fermi surface fluctuations near the first order transition can be strong.

When a repulsive constant contribution to the forward scattering interaction is added, the first order transition is suppressed and tricritical points at the ends of the second order transition line are shifted to lower T . Although the shift is usually not strong enough to lead to a quantum critical point (QCP), we find a limited parameter region where a QCP can be realized. In the weak coupling limit, the transition of the Fermi surface symmetry breaking is characterized by universal functions of suitably rescaled parameters.