TT 21: FS: Quantum Criticality in Strongly Correlated Metals

Time: Wednesday 9:30–13:00 Location: H20

Invited Talk TT 21.1 Wed 9:30 H20

Quantum Criticality, Kondo Breakdown, and Fermi Surfaces — •Qimiao Si — Dept of Physics & Astro, Rice U, Houston, TX, USA

Quantum criticality describes the collective fluctuations of matter undergoing a second order phase transition at zero temperature. Magnetic heavy fermion metals represent a prototype setting for quantum critical points (QCPs). Studies here have demonstrated quantum criticality as a mechanism for both non-Fermi liquid behavior and unconventional superconductivity. They have also illustrated the general notion of quantum criticality beyond the orthodox theory of order-parameter fluctuations. Here, I discuss these issues in the broader contexts, and address two types of antiferromagnetic QCPs, including a local quantum critical point [1] which contains the physics of a critical breakdown of the Kondo effect. Across such a QCP, there is a sudden collapse of a large Fermi surface to a small one. I also consider the proximate antiferromagnetic and paramagnetic phases, and these considerations lead to a global phase diagram [2]. Finally, I discuss the pertinent experiments, briefly address the case of ferromagnetic heavy fermions [3], and outline some issues for future studies.

[1] J.-X. Zhu, S. Kirchner, R. Bulla, & Q. Si, PRL 99, 227204 (2007) and to be published; Q. Si, S. Rabello, K. Ingersent & J. L. Smith, Nature 413, 804 (2001).

[2] Q. Si, arXiv:0912.0040; Physica B378, 23-27 (2006); S. J. Yamamoto and Q. Si, PRL 99, 016401 (2007).

[3] S. J. Yamamoto and Q. Si, arXiv:0812.0819.

Topical Talk TT 21.2 Wed 10:10 H20

Tuning magnetic quantum phase transitions — •Hilbert v. Löhneysen — Karlsruher Institut für Technologie, Physikalisches Institut und Institut für Festkörperphysik, D-76021 Karlsruhe

In the canonical quantum-critical heavy-fermion system (HFS) $CeCu_{6-x}Au_x$, a quantum critical point (QCP) can be obtained as a function of Au concentration at $x_c = 0.1$ or, for $x > x_c$, by hydrostatic pressure p or magnetic field B. The different behavior of B and x tuning of the QCP inferred from specific heat and resistivity, is corroborated by inelastic neutron scattering probing critical fluctuations [1], indicating that the (B, x, p) phase diagram for $T \to 0$ may exhibit several distinct phases. The Kondo temperature determined with UPS shows a sharp step at x_c, suggestive of a loss of complete Kondo screening [2]. Implications for QCP models for HFS will be discussed. - Uniaxial stress imposed on epitaxially grown $LaCoO_3$ films leads to the stabilization of a high-spin state, as opposed to bulk $LaCoO_3$ which is non-magnetic with S = 0 for $T \to 0$. Unexpectedly, ferromagnetism with T_C up to 80 K is observed in epitaxial films whose properties can be "strain-tuned" by choosing different substrates [3].

[1] O. Stockert et al., Phys. Rev. Lett. **99**, 237203 (2007)

[2] M. Klein et al., Phys. Rev. Lett. **101**, 266404 (2008)

[3] D. Fuchs et al., Phys. Rev. B **75**, 144402 (2007); B **77**, 014434 (2008)

Topical Talk TT 21.3 Wed 10:50 H20

Orbital-selective Mott transitions: Heavy Fermions and beyond — •Matthias Vojta — Institut für Theoretische Physik, Universität zu Köln, Germany

Quantum phase transitions in metals are often accompanied by non-Fermi liquid behavior and the appearence of novel phases in the vicinity of the quantum critical point. Among the interesting theoretical concepts is that of an orbital-selective Mott transition, which - in heavy-fermion metals - is equivalent to a breakdown of the Kondo effect. I will discuss aspects of both the quantum critical regime and the possibly emerging paramagnetic non-Fermi liquid phase, dubbed fractionalized Fermi liquid. Electron-lattice coupling can turn the orbital-selective Mott transition into a quantum version of the Kondo volume collapse. In addition, I will discuss the realization of fractionalized Fermi liquids in single-band models of correlated electrons, with an eye towards cuprate superconductors.

10 min. break

Topical Talk TT 21.4 Wed 11:40 H20

Interaction of the magnetic instability and the Fermi surface reconstruction in $YbRh_2Si_2$ — •Sven Friedemann[1], Tanja Westerkamp[1], Manuel Brando[1], Steffen Wirth[1], Niels Oeschler[1], Philipp Gegenwart[1,2], Cornelius Krellner[1], Christoph Geibel[1], Frank Steglich[1], Silke Bühler-Paschen[3], Stefan Kirchner[4,5], and Qimiao Si[5] — [1]MPI CPfS, Dresden, Germany — [2]I. Physik. Institut, Georg-August-Universität, Göttingen, Germany — [3]Institut für Festkörperphysik, TU Wien, Austria — [4]MPI PKS, Dresden, Germany — [5]Physics and Astronomy Department, Rice University, Houston, USA

An antiferromagnetic (AF) quantum critical point (QCP) is conventionally described by the quantum generalization of finite-temperature phase transitions. By contrast, the newly proposed unconventional scenarios for heavy-fermion metals are based on the breakdown of the Kondo effect. $YbRh_2Si_2$ is a prototype of the latter class. Here, we report high-precision Hall effect data demonstrating the coincidence of the Fermi surface reconstruction and the AF QCP in the stoichiometric compound. In addition, we present results revealing the global phase diagram of $YbRh_2Si_2$ under positive and negative chemical pressure as realized by Co and Ir substitution on the Rh side. Surprisingly, this leads to a detachment of the AF QCP from the Fermi surface reconstruction. In particular, negative pressure induces a separation of the two with an intermediate spin-liquid type ground state emerging in an extended field range. These results indicate a new quantum phase arising from the interaction of the Kondo breakdown and the AF QCP.

Topical Talk TT 21.5 Wed 12:20 H20

Novel electronic states near discontinous quantum phase transitions — •Philipp Gegenwart — I. Physikalisches Institut, Georg-August Universität Göttingen, Friedrich-Hund Platz 1, 37077 Göttingen

The collective low-energy excitations near quantum phase transitions (QPTs) lead to novel phenomena such as non-Fermi liquid (NFL) behavior, unconventional superconductivity or electronic nematicity. Here we focus on cubic ($Sr_{1-x}Ca_xRuO_3$) and layered ($Sr_3Ru_2O_7$) ruthenates. The former system, studied using thin films, displays a discontinuous ferromagnetic QPT with an extended NFL phase. In the latter system a novel phase displaying nematic-like transport anisotropies, which is bounded in magnetic field by two first-order metamagnetic transitions, is investigated by capacitive dilatometry on high-quality single crystals.

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