TT 23: CE: Quantum-Critical Phenomena 2

Time: Tuesday 10:30–13:00 Location: HSZ 105

TT 23.1 Tue 10:30 HSZ 105

Electrical transport properties of single-crystal $Nb_{1-y}Fe_{2+y}$ — •Max Hirschberger[1,2], William Duncan[3], Andreas Neubauer[2], Manuel Brando[4], Christian Pfleiderer[2], and Malte Grosche[1] — [1]Cavendish Laboratory, University of Cambridge, Cambridge, UK — [2]Physik-Department E21, Technische Universität München, Garching, Germany — [3]Department of Physics, Royal Holloway, University of London, Egham, UK — [4]Max-Planck-Institute for Chemical Physics of Solids, Dresden, Germany

The Laves phase system $Nb_{1-y}Fe_{2+y}$ displays a marginal Fermi liquid breakdown close to the critical composition $y_c = -0.015$ [1]. For $y > -0.015$ various bulk properties suggest the formation of hitherto unidentified electronic order at low temperatures akin a spin-density-wave (SDW) state. We have grown large single crystals of $Nb_{1-y}Fe_{2+y}$ by means of a bespoke image furnace. We present a study of the electrical transport properties of single-crystal $Nb_{1-y}Fe_{2+y}$ for three different compositions y and for a wide range of field orientations. All samples display strong anisotropy of the magnetoresistance between fields along the magnetically easy c-axis and the magnetically hard ab-plane. In a slightly iron-rich sample ($y = 0.006$) we observed a pronounced peak in the magnetoresistance for magnetic fields perpendicular to the c-axis in a temperature range from 10 to 30 K. We discuss possible explanations for this behaviour, such as the emergence of complex magnetic textures near the border of ferromagnetic quantum criticality.

[1] M. Brando et al, Phys. Rev. Lett. **101**, 026401 (2008); D. Moroni-Klementowicz et al., Phys. Rev. B **79**, 224410 (2009).

TT 23.2 Tue 10:45 HSZ 105

Uniform lattice distortion in the nematic phase of $Sr_3Ru_2O_7$ — •Christian Stingl and Philipp Gegenwart — I. Physikalisches Institut, Georg-August-Universität Göttingen

In the itinerant metamagnet $Sr_3Ru_2O_7$, a first order metamagnetic transition is suppressed to a quantum critical end point (QCEP) at $T = 0$ by applying a magnetic field $\mu_0 H_c = 7.85\,\mathrm{T}$ along the c-axis. Quantum critical behaviour is observed in thermal expansion and can be explained in terms of 2d ferromagnetic fluctuations [1].

Below 1 K, a new phase with a strongly enhanced residual resistivity forms in the vicinity of the QCEP. When H has a small in-plane component, the resistivity becomes anisotropic, which is discussed in terms of formation of an electronic nematic fluid organized into domains [2].

We present in-plane thermal expansion and magnetostriction measurements obtained by high-resolution capacitive dilatometry. Our findings suggest that inside the nematic phase, the four-fold symmetry is broken by a uniform lattice distortion with $\Delta L/L$ of the order of 10^{-6}. The results are discussed in the context of a recent model [3] for domain formation via partial orbital ordering.

This work is in collaboration with F. Weickert, R. Küchler, R.S. Perry and Y. Maeno and supported by the DFG through SFB602.

[1] P. Gegenwart et al., PRL **96**, 136402 (2006)
[2] R.A. Borzi et al., Science **315**, 214-217 (2007)
[3] W.-C. Lee and C. Wu, arXiv:1008.2486

TT 23.3 Tue 11:00 HSZ 105

Short range magnetic order close to a ferromagnetic quantum critical point in CeFePO — •Stefan Lausberg, Anton Jesche, Cornelius Krellner, Alexander Steppke, Luis Pedrero, Manuel Brando, Christoph Geibel, and Frank Steglich — Max Planck Institute for Chemical Physics of Solids, Nöthnitzer Str. 40, 01187 Dresden, Germany

The compound $CeFeAs_{1-x}P_xO$ combines strong 3d and 4f correlation effects. At $x = 0$ two antiferromagnetic (AFM) transitions were found. Iron orders at $T_{N,Fe} = 145$ K and cerium at $T_{N,Ce} = 3.7$ K. Increasing the chemical pressure by phosphorus substitution leaves $T_{N,Ce}$ almost unaffected while it shifts $T_{N,Fe}$ towards lower temperatures until it vanishes above $x = 0.35$. Further increasing phosphorus content induces ferromagnetic (FM) order of cerium at $T_c \approx 9$ K which is believed to suppress a superconducting state found in other iron pnictides when the iron AFM disappears. For $x \geq 0.6$, T_c decreases and finally vanishes in CeFePO which was reported to be a paramagnetic heavy fermion system close to a FM instability. However, tiny differences in sample preparation lead to the onset of short range magnetic order.

In this contribution we present low-temperature magnetization, specific heat and ac-susceptibility measurements of a polycrystaline CeFePO sample. The ac-susceptibility shows a peak at $T_f = 620$ mK which shifts towards higher temperatures by increasing the measuring frequency. We compare our results with the Kondo cluster glass $CePd_{1-x}Rh_x$ and discuss its properties in the frame of the quantum Griffiths phase scenario.

TT 23.4 Tue 11:15 HSZ 105

Thermodynamics of the spin-dimer $NiCl_2$-4SC$(NH_2)_2$ system at the magnetic-field-induced quantum phase transition — •Alexander Steppke[1], Robert Kuechler[1], Luis Pedrero[1], Manuel Brando[1], Armando Paduan-Filho[2], Christian Batista[3], Franziska Weickert[3], Vivien Zapf[3], Marcelo Jaime[3], and Frank Steglich[1] — [1]Max-Planck-Institut für Chemische Physik fester Stoffe, Nöthnitzer Str. 40, 01187 Dresden, Germany — [2]Instituto de Fisica, Universidade de Sao Paulo, Sao Paulo, Brazil — [3]Los Alamos National Laboratory, Los Alamos, USA

The concept of universality class in magnetic systems undergoing a quantum phase transition (QPT) can be tested in so-called quantum magnets, where the local spins are coupled forming ladders ($TlCuCl_3$), planes of dimers ($BaCuSi_2O_6$) or weakly coupled chains of $S = 1$ Ni atoms, as in the organic system $NiCl_2$-4SC$(NH_2)_2$ (DTN). In DTN the Ni^{2+} single ion anisotropy $D = 8.9$ K opens an energy gap between the $S_z = 0$ ground state and the $S_z = \pm 1$ first excited state. At a magnetic field $Hc_1 \approx 2\,\mathrm{T}$ the gap closes and a transition into an XY-antiferromagnetic ordered state is induced at low temperatures. Such a QPT belongs to the $d = 3$ and $z = 2$ universality class and the following theoretical laws are predicted: The magnetization $M \propto T^{d/z}$, the phase boundary line $(H - Hc_1) \propto T_c^{d/z}$, the thermal and magnetic Grüneisen ratios are expected to follow T^{-1}. We have investigated the temperature and field dependences of all these thermodynamic quantities in the temperature range $0.05 \leq T \leq 5\,\mathrm{K}$.

TT 23.5 Tue 11:30 HSZ 105

Spinon continuum and the ground state of the quantum kagome system — •Dirk Wulferding[1], Peter Lemmens[1], Shaoyan Chu[2], Tianheng Han[2], Young S. Lee[2], Yoshihiko Okamoto[3], Hiroyuki Yoshida[4], Zenji Hiroi[3], and Reizo Kato[5] — [1]IPKM, TU-BS, Braunschweig, Germany — [2]MIT, Massachusetts, USA — [3]ISSP, Tokyo, Japan — [4]NIMS, Tsukuba, Japan — [5]IPCR, Riken, Japan

We present a temperature dependent Raman study on different kagome lattice systems. At low temperatures, volborthite shows signs of structural distortions, while in the vesignieite spectra a low energy excitation appears that could be assigned to an emergent magnetic mode. We compare our results to the kagome model system herbertsmithite and discuss the effects of antisite disorder and lattice distortions.

Work supported by DFG, IGSM and NTH.

15 min. break

TT 23.6 Tue 12:00 HSZ 105

Electron self-energy near a nematic quantum critical point — •Markus Garst[1] and Andrey V. Chubukov[2] — [1]Institut für Theoretische Physik, Universität zu Köln, 50937 Köln — [2]Department of Physics, University of Wisconsin, Madison, 1150 University Avenue, Madison, Wisconsin 53706-1390, USA

We consider an isotropic Fermi liquid in two dimensions near a nematic instability in the charge channel [1]. Previous studies have found that such a system exhibits multiscale quantum criticality with two different energy scales associated with the different dynamics of the two polarization of the nematic order parameter [2]. We study the impact of the multiple energy scales on the electron Green's function. Apart from the common singular local self-energy of non-Fermi liquid form, we also find a logarithmically singular renormalizations of the quasiparticle residue Z and the vertex Γ. We derive and solve renormalization-group equations for the flow of Z and Γ , and show that the system develops an anomalous dimension at the nematic quantum critical point. As a result, the spectral function at a fixed ω and varying k has a non-Lorentzian form.

[1] M. Garst and A. V. Chubukov, Phys. Rev. B 81, 235105 (2010)

[2] M. Zacharias. P. Wölfle, and M. Garst, Phys. Rev. B 80, 165116 (2009)

TT 23.7 Tue 12:15 HSZ 105

Compressible Quantum Critical Metamagnetism — •Mario Zacharias[1], Indranil Paul[2], and Markus Garst[1] — [1]Institut für Theoretische Physik, Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Germany — [2]Institut Neel, CNRS/UJF, 25 avenue des Martyrs, BP 166, 38042 Grenoble, France

The coupling of critical fluctuations to the crystal lattice results in unusual dilatometric phenomena close to quantum phase transitions like, e.g., a diverging Grüneisen parameter. In certain cases, however, strong critical fluctuations are generically able to induce a distortion of the crystal lattice such that the quantum critical point gets preempted by a first-order structural transition. We argue that this applies for quantum critical metamagnetism as discussed in the context of $Sr_3Ru_2O_7$ and $CeRu_2Si_2$. Within an effective Ginzburg-Landau theory for itinerant quantum critical metamagnetism we discuss the resulting phase diagram and the experimental consequences.

TT 23.8 Tue 12:30 HSZ 105

Field-induced gap in a quantum spin-$\frac{1}{2}$ chain in a strong magnetic field — •M. Ozerov[1], J. Wosnitza[1], E. Čižmár[2], R. Feyerherm[3], S.R. Manmana[4,5], F. Mila[5], and S.A. Zvyagin[1] — [1]Hochfeld-Magnetlabor Dresden, Forschungszentrum Dresden-Rossendorf, Dresden, Deutschland. — [2]Centre of Low Temperature Physics, P.J. Šafárik University, Košice, Slovakia. — [3]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany. — [4]JILA, Department of Physics, University of Colorado, Boulder, Colorado, USA. — [5]Institute of Theoretical Physics, Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland.

Magnetic excitations in copper pyrimidine dinitrate, a spin-$\frac{1}{2}$ antiferromagnetic chain with alternating g-tensor and Dzyaloshinskii-Moriya interaction, that exhibits a field-induced spin gap, are probed by means of pulsed-field electron spin resonance spectroscopy. In particular, we report on a minimum of the gap in the vicinity of the saturation field $B_{sat} = 48.5$ T associated with a transition from the sine-Gordon region (with soliton-breather elementary excitations) to a fully spin-polarized state (with magnon excitations). This interpretation is fully confirmed by quantitative the agreement with DMRG calculations for a spin-$\frac{1}{2}$ Heisenberg chain with staggered transverse field.

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TT 23.9 Tue 12:45 HSZ 105

Quantum phase transition in the paired spin-boson model — •André Winter and Heiko Rieger — Theoretische Physik, Universität des Saarlandes, Campus, 66123 Saarbrücken

We study the quantum phase transitions occurring in a system of two two-level degrees of freedom (e.g. spin-1/2) each coupled to a bath of oscillators, denoted as the paired spin-boson model. Even in the absence of a direct interaction between the two spin-1/2s the dissipative bath establishes an effective interaction causing both mutual coherence effects and disspation. We perform large scale quantum Monte Carlo simulations based on a cluster algorithm in continuous imaginary time, which we applied already successfully to the single spin-boson model [1], to determine the phase diagram in the Ohmic and sub-Ohmic regime and use finite temperature scaling to determine the critical exponents. The extension to multiple spin-1/2 degrees of freedom and an infinite spin-1/2-chain coupled to a single dissipative bosonic bath are discussed.

[1] A. Winter, H. Rieger, M. Vojta, and R. Bulla, Phys. Rev. Lett. 102, 030601 (2009)