TT 65: Quantum-Critical Phenomena II

Time: Wednesday 15:00–18:30 Location: HFT-FT 131

TT 65.1 Wed 15:00 HFT-FT 131

Nematic phase transition of Dirac fermions — •Jonas Schwab[1], Kai Sun[2], Zi Yang Meng[3], Igor Herbut[4], and Fakher F. Assaad[1] — [1]Institut für Theoretische Physik und Astrophysik, Universität Würzburg, 97074 Würzburg, Germany — [2]Physics Department, University of Michigan, Ann Arbor, MI 48109, USA — [3]Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China — [4]Department of Physics, Simon Fraser University, Burnaby, British Columbia V5A 1S6, Canada

We consider Dirac fermions, as realized by a pi-flux tight binding model on a square lattice, coupled to an Ising model in a transverse field. The coupling is chosen such that the ordering of the Ising spins triggers a meandering of the Dirac fermions and thereby a nematic deformation of the "Fermi" surface. The model is amenable to sign-problem free quantum Monte Carlo simulations such that the nature of the transition for various couplings and flavor number of Dirac fermions can be analyzed in detail.

TT 65.2 Wed 15:15 HFT-FT 131

Investigation of magnetic fluctuations in the ferromagnet UGe_2 by means of Modulated Intensity by Zero Effort (MIEZE) — •Franz Haslbeck[1,2], Steffen Säubert[1,3], Christian Franz[3], Marc Janoschek[2,4], and Christian Pfleiderer[1] — [1]TU Munich, Germany — [2]Institute for Advanced Study, TU Munich, Germany — [3]MLZ, TU Munich, Germany — [4]LANL, USA

It is well known that the critical fluctuations associated with magnetic quantum critical points (QCP) are crucial for the emergence of novel states of matter such as unconventional superconductivity. However, their exact nature remains an outstanding question. Most notably, according to theory both the relaxation time and correlation length of the fluctuations are expected to diverge when the QCP is approached. However, to date this has not yet been observed, partially because this requires extreme energy and momentum transfer resolution. Here we show that for ferromagnetic QCPs this problem may be overcome using the newly developed longitudinal MIEZE (Modulated Intensity by Zero Effort) option at the instrument RESEDA at MLZ (Garching). To showcase the feasibility of this approach we have investigated the magnetic fluctuations in the material UGe_2 at ambient pressure in a small angle scattering geometry. Our results demonstrate that this technique allows studying ferromagnetic critical fluctuations with an energy resolution that is almost two orders of magnitude higher than for classical triple axis spectroscopy while simultaneously providing access to small momentum transfers. In conclusion, this suggests that MIEZE may be used to obtain new insights in ferromagnetic QCPs.

TT 65.3 Wed 15:30 HFT-FT 131

Exact solution of the spin-1/2 XXX chain with off-diagonal boundary fields — •Andreas Klümper and Dennis Wagner — Wuppertal University

The spin-1/2 Heisenberg chain with periodic boundary conditions is a seminal model of integrable resp. exactly solvable systems. It is known that the Heisenberg chain with arbitrary boundary fields is still integrable, but so far defied an explicit solution for the case of off-diagonal fields which break the $U(1)$ symmetry. As the magnetization is no longer a good quantum number, the direct application of the Bethe ansatz fails.

Here we show how the problem can be solved by a set of non-linear integral equations (NLIEs). Instead of two NLIEs as in the case of the periodically closed chain, we find a set of three NLIEs from which the eigenvalues of the Hamiltonian can be obtained. Finally, we present results for the spectrum in the conformal limit.

TT 65.4 Wed 15:45 HFT-FT 131

Tricriticality in the spin-1 XXZ chain with explicit bond dimerization — •Satoshi Ejima[1], Tomoki Yamaguchi[2], Florian Lange[1], Yukinori Ohta[2], and Holger Fehske[1] — [1]Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald, 17489 Greifswald, Germany — [2]Department of Physics, Chiba University, Chiba 263-8522, Japan

Applying the matrix-product-state based density-matrix renormalization group technique to the spin-1 XXZ chain with bond dimerization, we explore the competition between two different symmetry-protected-topological phases, Peierls and Haldane states. The bond dimerization narrows the Haldane phase, and only dimerized and Néel state survive for large dimerization. The critical line between these two states exhibits the continuous Ising transition with central charge $c = 1/2$, which terminates at a tricritical point, belonging to the universality class of the dilute Ising model with central charge $c = 7/10$. Above this point, the quantum phase transition becomes first order. We provide compelling evidence for the (tricritical) Ising quantum phase transition, simulating corresponding critical exponents, $\beta = 1/8$ (1/24) and $\nu = 1$ (5/9).

TT 65.5 Wed 16:00 HFT-FT 131

Spin and valence bond dynamics across a deconfined quantum critical point in a fermionic SU(3) model — •Zhenjiu Wang[1], Hui Shao[2], and Fakher.f Assaad[1] — [1]Institut for Theoretische Physik und Astrophysik, University Wuerzburg, Am Hubland, D-97074 Wuerzburg, Germany — [2]Beijing Computational Science Research Center, Beijing 100193, China

We consider a model of SU(3) fermions coupled to a transverse Ising field that harbors deconfined phases and phase transitions between antiferromagnetic (AFM) and valence bond solid (VBS) states [1]. Here, we supplement the model with a flux term and use the auxiliary field quantum Monte Carlo algorithm to and map out the phase diagram in the transverse field and flux plane. Special emphasis is placed on the VBS and AFM dynamics across the phase transition. An improved stochastic analytic continuation method reveals a spinon-continuum in the proximity of the DQCP.

TT 65.6 Wed 16:15 HFT-FT 131

Dimensional Corssover in a Bosonic Quantum Gas — •Dominik Strassel[1,2], Denis Morath[1], Polina Matveeva[1], Imke Schneider[1], Axel Pelster[1], and Sebastian Eggert[1] — [1]Department of Physics and Research Center Optimas, University Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Competence Center for High Performance Computing, Fraunhofer ITWM, 67663 Kaiserslautern, Germany

The emergence of new properties from low-dimensional building blocks is a universal theme in different areas in physics. Considering a $1D$–$3D$ transition, for instance, it is far from obvious if the power laws from the underlying $1D$ theory can predict the critical transition temperature, when it increases from zero as a function of inter-chain hopping [1]. Our model is represented by $1D$ tubes with hopping between them, which can be simulated in experiments with the help of optical lattices [2]. Combining large-scale Quantum Monte-Carlo simulations – using a canonical measurement – with analytical chain mean-field calculations and an effective potential approach to calculate the Landau potential, we show that the behavior of the critical ordering temperature as a function of the inter-chain hopping does not follow a universal power law of the known universality classes for fixed dimensions, but the exponents that we found can be interpreted as a novel type of scaling behavior.

[1] B. Irsigler and A. Pelster, Phys. Rev. A 95, 043610 (2017)
[2] A.Vogler, R. Labouvie, G. Barotini, S.Eggert, V. Guarrera, and H. Ott, Phys. Rev. Lett. 113, 215301 (2014)

15 min. break.

TT 65.7 Wed 16:45 HFT-FT 131

Microstructuring $YbRh_2Si_2$: Insights from low temperature resistance — •Alexander Steppke[1], Sandra Hamann[1], Markus König[1], Daniel Hafner[1], Andrew P. Mackenzie[1], Kristin Kliemt[2], Cornelius Krellner[2], and Manuel Brando[1] — [1]MPI for Chemical Physics of Solids, Noethnitzer Str. 40, 01187 Dresden — [2]Goethe-Universität Frankfurt, Max-von-Laue Strasse 1, 60438 Frankfurt am Main

In the prototypical Kondo lattice $YbRh_2Si_2$ signatures of quantum critical fluctuations, recently discovered superconductivity below 2 mK [1] and topological changes of the Fermi surface [2] are established from different experimental probes. Still absent are data of the resistive transition into the superconducting state and high-resolution magnetoresistance data to further investigate the topological transitions. Both face a similar challenge of measuring resistance with min-

imal dissipation at very low temperatures. We applied focused ion beam structuring to change the geometry and therefore increase the resistance, leading to both a higher resolution and reducing influences from contact resistances. First measurements exhibit an order of magnitude improvement in resolution, revealing quantum oscillations at high applied fields. Additionally the controlled geometry is a first step to explore in-plane strain to change the magnetic properties in the vicinity of the quantum critical point.

[1] E. Schuberth et al., Science 351, 485 (2016).
[2] H. Pfau et al., PRL 110, 25 (2013).

TT 65.8 Wed 17:00 HFT-FT 131

Superconductivity and Quantum Critical Behavior in the antiferromagnetically ordered Heavy Fermion Compound Ce_3PtIn_{11}. — Jan Prokleška, Marie Kratochvílová, Klára Uhlířová, Vladimír Sechovský, and •Jeroen Custers — Faculty of Mathematics and Physics, Charles University, DCMP, Ke Karlovu 5, 121 16 Praha 2, Czech Republic

Ce_3PtIn_{11} (tetragonal, space group P4/mmm). The material belongs to the $Ce_nT_mIn_{3n+2m}$ class of layered materials which comprises a numerous amount of compounds including $CeCoIn_5$ and $CeRhIn_5$. At ambient condition the material shows remarkable properties: in the absence of magnetic field, Ce_3PtIn_{11} undergoes two successive magnetic transitions at $T_1 = 2.2$ K and $T_N = 2.0$ K, respectively, and becomes superconducting (SC) below $T_c = 0.35$ K. Upon applying hydrostatic pressure (p) T_1 and T_N reduce and intersect with the SC state at $p \approx 1.1$ GPa. Extrapolation of $T_N \to 0$ reveals a critical pressure of $p_c = 1.3$ GPa, i. e., the quantum critical point (QCP). Here, T_c is maximum. This strongly suggests that critical fluctuations associated with the magnetic QCP are responsible for Cooper-pairing. A salient detail with respect to the interplay of magnetism and superconductivity is that Ce_3PtIn_{11} possesses two non-equivalent Ce-sites. Ce2 resides the Wyckoff 1a place (C_{4v} symmetry). The ion is experiences $CeIn_3$ environment ($CeIn_3$ is an AFM). The Ce1-site occupies the 2g position (D_{4h} symmetry). Its surrounding is identical to Ce-atoms in Ce_2PtIn_8 (superconductor).

TT 65.9 Wed 17:15 HFT-FT 131

$CeRh_2As_2$: a Ce-based Kondo-lattice system very close to a possible multipolar quantum critical point — •Seunghyun Khim[1], Jacintha Banda[1], Daniel Hafner[1], Dongjin Jang[1,2], Manuel Brando[1], and Christoph Geibel[1] — [1]Max Planck Institut für Chemische Physik fester Stoffe, Dresden, Germany — [2]Max Planck-POSTECH/KOREA Center for Complex Phase Materials, Pohang, Republic of Korea

We have recently grown single crystals of the new compound $CeRh_2As_2$ and studied its physical properties. Resistivity, specific heat (C_p) and magnetic susceptibility results evidence a strong Kondo interaction with $T_K \sim 25$ K. At zero field, two transitions occur at $T_1 \sim 0.2$ K and $T_2 \sim 0.3$ K. T_1 and T_2 much smaller than T_K place this system very close to a hybridization induced quantum critical point (QCP). With magnetic fields T_1 is gradually suppressed, suggesting its magnetic origin. T_2, on the other hand, increases slowly with fields, similar to the quadrupolar order in CeB_6. The suggestive quadrupolar order at T_2 is compatible with high-T C_p data that imply an effective quasi-quartet ground state which provides a quadrupolar degree of freedom. Therefore our result indicate $CeRh_2As_2$ to be a unique Kondo-lattice system of strong potential relevance for the multipolar QCPs.

TT 65.10 Wed 17:30 HFT-FT 131

Highly anisotropic strain dependencies in $PrIr_2Zn_{20}$ — •Andreas Wörl[1], Takahiro Onimaru[2], Yoshifumi Tokiwa[1], Keisuke Matsumoto[2], Toshiro Takabatake[2], and Philipp Gegenwart[1] — [1]Experimentalphysics VI, Center for Electronic Correlations and Magnetism, University of Augsburg, Germany — [2]Graduate School of Advanced Sciences of Matter, Hiroshima University, Japan

Exotic Kondo physics, driven by the hybridization between electric quadrupole moments and conduction electrons, generates novel metallic phases. In $PrIr_2Zn_{20}$ the local T_d symmetry of the Pr-ions forms the non-Kramers ground-state doublet which is a key prerequisite to explore quadrupole driven states of matter. The material displays antiferroquadrupolar order at $T_Q = 0.11$ K, which is suppressed by magnetic fields $B \leq 5$ T applied along the [001] direction. Superconductivity sets in at $T_c = 0.05$ K. The significant enhancement of Seebeck coefficient as well as anomalies in specific heat and electrical resistivity at the critical magnetic field at $B = 5$ T prompted speculations about a quadrupolar quantum critical point. To clarify potential quadrupolar quantum criticicality, we investigated thermal expansion and magnetostriction parallel and perpendicular to magnetic fields $\boldsymbol{B} \parallel [001]$. Linear thermal expansion and magnetostriction display huge uniaxial anisotropy, whereby volume changes are vanishingly small. We conclude that magnetic field is not an effective parameter to tune the hybridization of localized $4f^2$ and conduction electrons in $PrIr_2Zn_{20}$ and exclude the formation of a quadrupolar quantum critical point at $B \approx 5$ T.

TT 65.11 Wed 17:45 HFT-FT 131

Critical phenomena in the honeycomb antiferromagnet $BaNi_2V_2O_8$ — •Ekaterina Klyushina[1,2], Bella Lake[1,2], Johannes Reuther[1,3], Nazmul Islam[1], Bastian Klemke[1], and Martin Mansson[4,5] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany — [2]Institut für Festkörperphysik Technische Universität Berlin, Germany — [3]Freie Universität, Berlin, Germany — [4]Materials Physics, KTH Royal Institute of Technology, Stockholm Kista, Sweden — [5]Laboratory for Neutron Scattering & Imaging, Paul Scherrer Institute, Villigen, Switzerland

Here we investigate the critical phenomena in the quasi-two dimensional (2D) Heisenberg honeycomb antiferromagnet $BaNi_2V_2O_8$. Both the temperature regions below and above ordering temperature T_N were explored using the technique of neutron diffraction. The critical exponent of the order parameter and the thermal decay of the correlation length were measured and analysed by applying several theoretical approaches. The temperature dependence of the spontaneous magnetization is found to follow the power law predicted for a 2D XY magnetic system confirming the 2D planar character of $BaNi_2V_2O_8$ even below T_N. At the high temperatures, the thermal decay of the correlation length is fitted well by the 2D isotropic Heisenberg approach, however the agreement becomes worse when the temperature is close to T_N. Indeed, only the expression derived by Berezinskii, Kosterlitz and Thousless is found to be in a good agreement with the experimental data within the temperature range just above the T_N. This result suggests the presence of a free vortex phase close to T_N.

TT 65.12 Wed 18:00 HFT-FT 131

Coherent low energy resonant excitation of heavy-fermion systems — •Shovon Pal[1], Christoph Wetli[1], Johann Kroha[2], Cornelius Krellner[3], Kristin Kliemt[3], Oliver Stockert[4], Hilbert v. Loehneysen[5], and Manfred Fiebig[1] — [1]ETH Zurich — [2]Bonn University, Germany. — [3]Goethe University Frankfurt, Germany. — [4]MPI Dresden, Germany. — [5]KIT, Germany.

Quantum phase transitions (QPT) describe a change between two ground states of a many-body system resulting from quantum fluctuations. Rare-earth heavy-fermion systems such as $CeCu_{6-x}Au_x$ show a QPT between a fully Kondo-screened paramagnetic Fermi-liquid phase and an antiferromagnetically (AFM) ordered phase. When excited by THz pulses, the system disintegrates near the QPT and coherently recovers on timescales in the order of picoseconds, characteristic to the Kondo temperature. We use THz time-domain spectroscopy to probe Kondo quasi-particle spectral weight at such ultrafast timescales. Temperature-dependent examination of samples with different Au concentrations reveals that in the heavy fermion ($CeCu_6$) and the quantum critical ($CeCu_{5.9}Au_{0.1}$) samples, the Kondo weight first shows a logarithmic increase by lowering the temperature until 30 K, followed by a decrease as we enter the quantum critical regime below the Kondo temperature. While in $CeCu_{5.9}Au_{0.1}$ the Kondo weight is destroyed below 5 K, $CeCu_6$ shows a drop of about 40%. The $CeCu_5Au$ sample being deep in the AFM phase does not exhibit visible Kondo weight at any temperatures despite the fact that low-temperature specific heat measurements reveal a sizeable Fermi-liquid-like contribution.

TT 65.13 Wed 18:15 HFT-FT 131

Slow dynamics around the field-induced quantum critical points in the organic spin-dimer system $C_{28}H_{32}N_4O_2$ (BY310) — •Paul Eibisch[1], Lars Postulka[1], Bernd Wolf[1], Ulrich Tutsch[1], Yulia Borozdina[2], Martin Baumgarten[2], and Michael Lang[1] — [1]Physikalisches Institut Geothe-Universität — [2]Max Planck Institut für Polymerforschung

Interacting spin-dimer networks exhibit a vast diversity of exotic physical states in connection with a field-induced ordered phase between two quantum critical points. Examples include Bose-Einstein-condensates of magnetic excitations for 3D systems as well as Luttinger liquids in 1D or BKT topological order in 2D. Spin-dimer systems, based on organic radicals, represent suitable candidates to explore this physics due

to their high degree of tunability in terms of interaction strengths and dimensionality. We present results of the specific heat, susceptibility and magnetic Grüneisen parameter of the organic spin-dimer system $C_{28}H_{32}N_4O_2$, consisting of tolane-bridged iminio nitroxide radicals. Measurements were performed in a field range up to 6 T and for temperatures down to 30 mK. A field-induced ordered phase was found at fields between 1.86 T and 4.3 T for temperatures $T \leq 540$ mK. Of particular interest is the observation made in AC susceptibility at $T < 1$ K which indicates very slow dynamics of the spin system in the vicinity of both quantum critical points.