TT 50: Correlated Electrons: Quantum-Critical Phenomena - Theory

Time: Tuesday 14:00–16:00 Location: BEY 81

TT 50.1 Tue 14:00 BEY 81

Detailed analysis of critical points in coupled spin dimer systems — •Sebastian Eggert[1], Dominik Strassel[1], and Peter Kopietz[2] — [1]Fachbereich Physik, Technische Universität Kaiserslautern — [2]Fachbereich Physik, Goethe Universität Frankfurt

Spin dimer systems are a promising playground for the detailed study of quantum phase transitions. In many cases it is sufficient to use the magnetic field as the tuning parameter in order to reach interesting non-trivial critical points. Depending on the temperature it is in principle possible to observe a crossover from the characteristic scaling near the critical point to the behavior of a finite temperature phase transition. In order to quantitatively demonstrate those effects and inspired by recent experiments we have started large scale quantum Monte Carlo simulations in order to analyze several different physical quantities in spin dimer systems, namely the susceptibility, the magneto-caloric effect, the structure factor and the spin stiffness. We discuss in detail how the phase transitions (quantum and finite temperature) are manifest in the characteristic scaling behavior near critical points by comparing them with interacting boson theories. The results give a unified picture of the full quantum and finite temperature phase diagram.

TT 50.2 Tue 14:15 BEY 81

Quantum Monte Carlo Simulations of Trimerized Antiferromagnetic Systems — •Dominik Strassel and Sebastian Eggert — Department of Physics and Research Center Optimas, Technical University Kaiserslautern, 67663 Kaiserslautern, Germany

We study linear clusters of three strongly coupled spins $\mathcal{S} = \frac{1}{2}$ (trimers), which are connected more weakly in a two dimensional lattice using *Stochastic Series Expansion Quantum Monte Carlo* simulations of the Heisenberg model in a magnetic field. In general these systems show a magnetization plateau at $\frac{1}{3}$ saturation, which is already known from strongly coupled three-leg ladders. Interestingly, the origin of the plateau is very similar to the $\frac{1}{3}$ plateau in frustrated lattices (e.g. the triangular lattice) so that the analogous phase transitions can be analyzed using non-frustrated systems, which do not suffer from the infamous minus sign problem. With increasing coupling between the trimers, the plateau vanishes and a critical point can be identified. We also analyze the behavior in the limit of weak inter-trimer coupling.

TT 50.3 Tue 14:30 BEY 81

Excitonic Instability at Spin-State Transition — •Jan Kuneš and Pavel Augustinský — Institute of Physics, ASCR, Prague, Czechia

We report a newly observed instability of the half-filled two-band Hubbard model in the vicinity of the spin-state transition. [1] Using dynamical mean-field theory we have performed a unbiased search for divergent particle-hole susceptibilities. Depending on the bandwidths ratio the system was found to establish a checker-board order of high- and low-spin sites, breaking the discrete translational symmetry, or to undergo a condensation of spinful excitons, breaking a continuous gauge symmetry. Besides numerical results we provide an analytic description in the strong-coupling limit where the problem maps of a variate of the bosonic t-J model.

[1] Kunes and Augustinsky, arXiv:1310.0669

TT 50.4 Tue 14:45 BEY 81

Critical phenomena of the two-channel spin-boson model — •Benedikt Bruognolo[1], Andreas Weichselbaum[1], Jan von Delft[1], and Matthias Vojta[2] — [1]Physics Department, Arnold Sommerfeld Center for Theoretical Physics and Center for NanoScience, Ludwig-Maximilians-Universität München, 80333 München, Germany — [2]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany

In recent years bosonic quantum impurity models have attracted significant attention in the context of quantum phase transitions. Numerical approaches to study the critical properties in such models face additional challenges arising from the bosonic nature of the bath modes, that are not present in purely fermionic systems.

Guo et al. [1] presented a powerful numerical method based on a combination of NRG and DMRG, which overcomes the problem of a diverging bosonic state space by variationally constructing an optimized boson basis on each site of the Wilson chain. We discuss a symmetry improved application of this method to the sub-ohmic spin-boson model with two symmetrically coupled bosonic baths and focus on its critical properties, which so far had been an open question. We present the first numerical study of the critical points, which in combination with RG results allows a description of the critical phenomena of this model for a wide range of parameters.

[1] C. Guo, A. Weichselbaum, J. von Delft, M. Vojta, Phys. Rev. Lett. 108, 160401 (2012)

TT 50.5 Tue 15:00 BEY 81

Interplay of fermion and boson induced critical Kondo destruction — •Farzaneh Zamani[1,2], Pedro Ribeiro[1,2,3], and Stefan Kirchner[1,2] — [1]MPI-PKS, Dresden, Germany — [2]MPI-CPFS, Dresden, Germany — [3]CFIF-IST, Universidade de Lisboa, Lisboa, Portugal

An increasing number of experiments have indicated that the traditional approach to continuous zero-temperature phase transitions in strongly correlated electrons systems is inadequate. In the context of intermetallic rare-earth compounds this approach does e.g. not account for the linear-in-temperature relaxation rates observed in a number of systems in the charge- and spin-response near criticality. A widely discussed alternative to the standard approach picture is local Kondo destruction, where Kondo screening becomes critical concomittantly with the lattice. We study the phenomenon of critical Kondo destruction in the pseudogap Bose-Fermi Kondo model where a quantum spin is coupled to a fermionic and a bosonic bath. Each of the baths by itself is capable of critically destroying Kondo screening, allowing us to study the dynamic interplay of the two. We employ a dynamic large-N limit and obtain asymptotically exact solutions at zero temperature. We also report full scaling equations at all critical points and discuss the ensuing relaxation rates. Finally, we revisit the issue of 'conformal scaling' of the imaginary-time correlation functions at criticality and relate our findings to their counterpart in the easy-axis pseudogap pseudogap Bose-Fermi Kondo model.

TT 50.6 Tue 15:15 BEY 81

Corrections to scaling in the critical theory of deconfined criticality — •Lorenz Bartosch — Institut für Theoretische Physik, Universität Frankfurt, 60438 Frankfurt am Main, Germany

Inspired by recent conflicting views on the order of the phase transition from an antiferromagnetic Néel state to a valence bond solid, we use the functional renormalization group to study the underlying quantum critical field theory which couples two complex matter fields to a non-compact gauge field. In our functional renormalization group approach we only expand in covariant derivatives of the fields and use a truncation in which the full field dependence of all wave-function renormalization functions is kept. While we do find critical exponents which agree well with some quantum Monte Carlo studies and support the scenario of deconfined criticality, we also obtain an irrelevant eigenvalue of small magnitude, leading to strong corrections to scaling and slow convergence in related numerical studies.

TT 50.7 Tue 15:30 BEY 81

Heavy fermion quantum critical point from AdS/CFT correspondence — •Mihailo Čubrović — Institute for Theoretical Physics, University of Cologne, Germany

We propose a holographic (AdS/CFT) approach to strongly correlated electrons and study a quantum phase transition from small to large Fermi surface phase in a model "heavy fermion" system. AdS/CFT is a duality which maps the correlation functions from field theory to solutions of the equations of motion for classical fields in a curved spacetime, i.e. in general relativity. The appealing side of this approach is its nonperturbative nature: the calculations on the gravity side are essentially an expansion in inverse coupling strength and indeed work best in the strong coupling regime. We construct a gravity dual of a Fermi liquid system which shows a mass enhancement of the order of several hundred times the bare mass. At zero temperature, the system exhibits a continuous quantum phase transition to another Fermi liquid with different effective mass and Fermi momentum. The difference in sizes of the Fermi surfaces (i.e. Fermi momenta), as well as the fact that the transition happens at finite wavevector agree with the intuition on heavy fermion transitions. While the picture resembles the fractionalization scenario, we.do not introduce any emergent gauge fields. The shrinking of the Fermi surface can best be interpreted as formation of bound states between electrons and exotic bosonic excitations near the quantum critical point.

TT 50.8 Tue 15:45 BEY 81

Anderson Metal-Insulator Transitions With Classical Magnetic Impurities — •Daniel Jung[1], Keith Slevin[2], and Stefan Kettemann[1,3] — [1]School of Engineering and Science, Jacobs University Bremen, 28759 Bremen, Germany. — [2]Department of Physics, Graduate School of Science, Osaka University, 1-1 Machikaneyama, Toyonaka, Osaka 560-0043, Japan. — [3]Division of Advanced Materials Science, Pohang University of Science and Technology (POSTECH), Pohang 790-784, South Korea.

We study the effects of classical magnetic impurities on the Anderson metal-insulator transition numerically [1, 2]. In particular we find that while a finite concentration of Ising impurities lowers the critical value of the site-diagonal disorder amplitude W_c, in the presence of Heisenberg impurities, W_c is first enhanced with increasing exchange coupling strength J due to time-reversal symmetry breaking. The resulting scaling with J is analyzed and compared to analytical predictions by Wegner [3]. We discuss the relevance of our findings for systems like phosphor-doped silicon, which are known to exhibit a quantum phase transition from metal to insulator driven by the interplay of both interaction and disorder, accompanied by the presence of a finite concentration of magnetic moments [4].

[1] D. Jung, and S. Kettemann, AIP conf. proceed., submitted.
[2] D. Jung, K. Slevin, and S. Kettemann, to be published.
[3] F. Wegner, Nucl. Phys. B **280**, 210 (1987).
[4] H. von Löhneysen, Adv. Solid State Phys. **40**, 143 (2000)