# TT 48: Correlated Electrons: Quantum-Critical Phenomena - Theory

Time: Wednesday 16:45–18:45 Location: H19

**Topical Talk** TT 48.1 Wed 16:45 H19

**Transport as a sensitive indicator for quantum criticality** — •Gernot Schaller, Malte Vogl, and Tobias Brandes — Institut für Theoretische Physik, TU Berlin, Berlin, Germany

Quantum-critical systems exhibit a non-analytic behavior of the ground state with respect to an external control parameter, separating macroscopically different phases. At zero temperature, this is transfered to order parameters such as e.g. the energy or other observables. However, when dealing with fragile quantum systems one has to take the inevitable interaction with a reservoir into account. The fate of the quantum criticality in this regime is less understood.

We argue that due to the closure of the energy gap above the ground state, at finite reservoir temperatures the non-analytic ground state properties will be suppressed in most observables. This can also be expected in non-equilibrium setups, where the system is placed in contact with multiple thermal reservoirs at different temperatures. In contrast, we propose the stationary current through the quantum-critical system itself (e.g. the heat current transferred between the reservoirs through the system) to be much more sensitive to quantum criticality: We expect signatures in the stationary current even in the far from equilibrium regime. These findings are made explicit at a toy model for adiabatic computation corresponding to a first order quantum phase transition and at the quantum Ising model in a transverse field with a second order quantum phase transition.

[1] M. Vogl, G. Schaller, and T. Brandes, Phys. Rev. Lett. (in press), arXiv:1208.5989 (2012).

TT 48.2 Wed 17:15 H19

**Conductivity close to antiferromagnetic criticality** — Sergey Syzranov and •Jörg Schmalian — Institut für Theorie der Kondensierten Materie, Karlsruher Institut für Technologie

We study the conductivity of a three dimensional disordered metal close to an antiferromagnetic instability within the framework of the spin-fermion model[1]. We calculate the interaction correction to the conductivity, assuming that the latter is dominated by disorder scattering, and the interaction is weak. Although the fermionic scattering rate shows critical behaviour on the entire Fermi surface, the interaction correction is dominated by processes near the hot spots, narrow regions of the Fermi-surface corresponding to the strongest spin-fermion scattering. We discuss the scaling behavior of the conductivity as function of frequency and temperature and the role of quantum corrections to the semi-classical Boltzmann theory of transport.

[1] S. Syzranov, and J. Schmalian, Phys. Rev. Lett. 109, 156403 (2012)

TT 48.3 Wed 17:30 H19

**Universal short time dynamics after a quantum quench in the vicinity of a quantum critical point** — •Pia Gagel, Peter Orth, and Jörg Schmalian — Institut für Theorie der Kondensierten Materie, Karlsruher Institut für Technologie

We investigate the dynamical evolution of the order parameter after a quantum quench from the ordered state to the quantum critical point. The calculation is done for a model relevant for quantum magnets and bosons near the superfluid insulator transition. The short time dynamics after a quantum quench is, similar to quenches near classical phase transitions, characterized by a new universal exponent. We determine this exponent using a 4-d-z and 1/N expansions and by mapping the system onto boundary layer problems. Here d is the space dimension, z the dynamic scaling exponent, and N the number of components of the order parameter. Thermalization of the post quantum quench dynamics then leads to a sequence of distinct temporal regimes that are qualitatively distinct from classical quenches. Our results demonstrate that the post quench dynamics can be used to determine the universality class of a quantum critical point.

TT 48.4 Wed 17:45 H19

**Kondo breakdown in RKKY-coupled two- and multi-impurity Kondo systems** — •Ammar Nejati, Katinka Ballmann, and Johann Kroha — Universität Bonn

The driving mechanisms for magnetic quantum phase transitions in different heavy fermion systems have remained obscure. One difficulty is the lack of theoretical methods for treating a possible breakdown of Kondo screening and of heavy quasiparticles without invoking magnetic order. We consider a dense system of Kondo impurities and develop a novel renormalization group technique for the local Kondo coupling $J_i$ on a given impurity site $i$. At the one-loop level, the $\beta$ function for $J_i$ includes RKKY corrections due to the coupling to the surrounding impurities $j \neq i$, which arises in order $O(J_i J_j)$ from the local couplings $J_i$ and $J_j$. In this way, double counting of RKKY operators is avoided. This method allows to determine the single-impurity Kondo screening scale $T_K(y)$ as a function of the dimensionless RKKY coupling $y$ (determined alone by the conduction electron response function), without invoking magnetic ordering fluctuations. The solution of the RG equation indicates a breakdown of Kondo screening when $y$ exceeds a critical value $y_c$, where the latter can be expressed in a universal way in terms of the bare Kondo temperature $T_K(y=0)$. For $y < y_c$ the RKKY-corrected single-impurity Kondo screening scale $T_K(y)/T_K(0)$ is a universal function of $y/y_c$ [1]. We compare these predictions with recent experiments on heavy fermion [1] and two-impurity [2] systems.

[1] M. Klein *et al.*, PRL **101**, 266404 (2008)
[2] J. Bork *et al.*, Nature Physics **7**, 901 (2011)

TT 48.5 Wed 18:00 H19

**Quantum Criticality in the two-channel pseudogap Anderson model** — •Farzaneh Zamani[1,2], Tathagata Chowdhury[3], Pedro Ribeiro[1,2], Kevin Ingersent[3], and Stefan Kirchner[3] — [1]Max Planck Institute for the Physics of Complex System, Nöthnitzer Str. 38, D-01187 Dresden, Germany — [2]Max Planck Institute for Chemical Physics of Solids, Nöthnitzer Str. 40, D-01187 Dresden, Germany — [3]Department of Physics, University of Florida, Gainesville, Florida 32611-8440, USA

The two-channel Anderson impurity model with a density of states $\rho(E) \propto |E|^r$ that vanishes at the Fermi energy (E = 0) is of current interest in connection with impurities in graphene and in unconventional superconductors. We study the dynamical properties of the two-channel Anderson model using the non-crossing approximation (NCA), and compare our results against the numerical renormalization-group (NRG) method. This model shows continuous quantum phase transitions between weak- and strong-coupling phases. The NCA is shown to reproduce the correct qualitative features of the pseudogap model, including the phase diagram, and to yield critical exponents in excellent agreement with the NRG and exact results. The forms of the dynamical magnetic susceptibility and impurity Green's function at the fixed points are suggestive of frequency-over-temperature scaling, another aspect associated with interacting quantum critical points.

TT 48.6 Wed 18:15 H19

**Charge order in the Falicov-Kimball model - a dual fermion approach** — •Andrey Antipov[1,2], Emanuel Gull[3], and Stefan Kirchner[1,2] — [1]Max Planck Institute for Chemical Physics of Solids, Nöthnitzer Straße 40, 01187 Dresden, Germany — [2]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden, Germany — [3]Department of Physics, University of Michigan, Ann Arbor, Michigan 48109, USA

We study charge ordering in the Falicov-Kimball model in 2,3,4, and infinite dimensions within the dynamical mean field theory (DMFT) and its recently developed dual fermion extension, which allows for the systematic diagrammatic description of the spatial corrections to the DMFT solution. We focus on the critical properties of the model and compare various levels of approximations. The Falicov-Kimball model is particularly well suited to this purpose as the reducible n-point vertices entering a dual fermion calculation can be constructed analytically from the exactly solvable DMFT limit. We make a comparison to exactly known results.

TT 48.7 Wed 18:30 H19

**Matrix Product States with Long-Range Localizable Entanglement** — •Thorsten Wahl[1], David Pérez-García[2], and Ignacio Cirac[1] — [1]Max-Planck Institut für Quantenoptik, Hans-Kopfermann-Str. 1, Garching, D-85748, Germany — [2]Departamento de Analisis Matematico, Universidad Complutense de Madrid, 28040 Madrid, Spain

Localizable entanglement is the maximum amount of entanglement that can be generated between two spins of a spin chain by measuring the remaining ones. The case of long-range localizable entanglement, where this amount is finite even if the two spins are infinitely far apart, constitutes a hidden long-range order and is important for quantum repeaters and the characterization of quantum phase transitions. A criterion will be presented which characterizes the full set of Matrix Product States with long-range localizable entanglement.