TT 25 Correlated Electrons - Low-dimensional Systems: Models

Zeit: Dienstag 09:45–13:00 Raum: TU H2053

TT 25.1 Di 09:45 TU H2053

Finite-frequency transport properties of dimerized and frustrated spin-1/2 chains — •Fabian Heidrich-Meisner, Andreas Honecker, and Wolfram Brenig — Technische Universität Braunschweig, Institut für Theoretische Physik, Mendelssohnstraße 3, 38106 Braunschweig

We present a numerical study of both spin and thermal transport in dimerized and frustrated spin-1/2 chains at finite temperatures. Since both models are nonintegrable, the Drude weights scale to zero in the thermodynamic limit [1]. We therefore focus on the behavior of the conductivities at finite frequencies, studying the scaling with system size as well as the extrapolation to the zero-frequency limit. Results for three examples are presented. First, the dimerized chain is studied in the limit of weakly coupled dimers. In this case, interactions of the elementary triplet excitations are weak, which allows us to compute the life-times of the energy and the spin current analytically in a perturbative scheme within a bond-boson operator representation. Second, we compare the conductivities of the frustrated chain in the massless and the massive regime of this model. Finally, we extract the zero-frequency thermal conductivity of the isotropic two-leg spin ladder from the numerical data and suggest a comparison with experimental results for $La_5Ca_9Cu_{24}O_{41}$ [2].

[1] F. Heidrich-Meisner et al., Phys. Rev. B 68, 134436 (2003).
[2] C. Hess et al., Phys. Rev. B 64, 184305 (2001).

TT 25.2 Di 10:00 TU H2053

Adaptive time-dependent DMRG: simulating the dynamics of strongly correlated systems — •Ulrich Schollwöck — Institut für Theoretische Physik C, RWTH Aachen, 52056 Aachen

The integration of concepts from quantum information theory has recently allowed the extension of DMRG to the high-precision calculation of the time-evolution of one-dimensional strongly correlated quantum systems at low algorithmic cost (Daley, Kollath, Schollwoeck, Vidal and White, Feiguin). The key idea is that the reduced Hilbert space generated by DMRG does not remain static in time or is enlarged at substantial computational cost, but adapts itself optimally to the time-evolving quantum state. I want to present the potential of this method for the calculation of far-from-equilibrium time-evolutions of quantum spin chains as well as the time-evolution of electronic models.

TT 25.3 Di 10:15 TU H2053

Adaptive time-evolution with DMRG for low dimensional correlated systems — •Salvatore Manmana[1,2], Alejandro Muramatsu[1], and Reinhard Noack[2] — [1]Institut für Theoretische Physik III, Universität Stuttgart, Pfaffenwaldring 57/V, 70550 Stuttgart — [2]AG Vielteilchennumerik, Fachbereich Physik, Philipps-Universität Marburg, 35032 Marburg

Only little is known about the physics of time-dependent problems in the field of strongly correlated quantum systems due to the lack of effective controlled approaches. Recently there has been progress in this direction for one dimensional systems. We present further developments in the construction of numerical schemes, in particular using exact diagonalization techniques and the density matrix renormalization group method (DMRG), which can be applied to correlated low-dimensional systems. Results for the collapse and revival of the metallic state in systems of spinless fermions with nearest-neighbour-interaction are discussed and the accuracy of these methods is compared with exact results.

TT 25.4 Di 10:30 TU H2053

Charge inhomogeneities in the one-dimensional *t-J* model — •D. Pertot, J. Hub, C. Lavalle, and A. Muramatsu — Institut für Theoretische Physik III, Universität Stuttgart, Pfaffenwaldring 57, D-70550 Stuttgart

We study phase separation and related phenomena in the one-dimensional *t-J* model using a recently performance-improved version of our hybrid-loop QMC algorithm [1], which combines the loop and determinantal algorithms. The boundary of the phase-separated regime is determined and compared with previous results obtained by different techniques. In the phase-separated regime we find low energy spatially charge-ordered excited states ($\Delta E \ll J$). These excited states can be thought of as the electron-rich region of the phase-separated ground state being split up into multiple electron-rich regions with hole-rich regions in between. We discuss the behavior of the excitations far away from and close to the phase separation boundary when approaching the thermodynamic limit. Possible implications for experimental observations of charge-ordering in cuprates are pointed out.

[1] C. Lavalle *et al.*, Phys. Rev. Lett. **90**, 216401 (2003)

TT 25.5 Di 10:45 TU H2053

Anomalous self-energy and Fermi surface quasi-splitting in the vicinity of a ferromagnetic instability — •Andrey Katanin[1,2] and Arno Kampf[3] — [1]Max-Planck-Institut fuer Festkoerperforschung, 70569 Stuttgart, Germany — [2]Institute of Metal Physics, 620219 Ekaterinburg, Russia — [3]Institut fuer Physik, Theoretische Physik III, Elektronische Korrelationen und Magnetismus, Universitaet Augsburg, 86135 Augsburg, Germany

We discuss the low-temperature behavior of the electronic self-energy in the vicinity of a ferromagnetic instability in quasi-dimensional systems. We show, that in the paramagnetic phase, where the long-range magnetic order is absent, the self-energy has a non-Fermi liquid form at low energies $|\omega| < \Delta_0$ near the Fermi level, where Δ_0 is the ground-state spin splitting. The spectral function at temperatures $T < \Delta_0$ has a two-peak structure with finite spectral weight at the Fermi level. The simultaneous inclusion of self-energy and vertex corrections shows that the above results remain qualitatively unchanged down to very low temperatures $T_C < T \ll \Delta_0$. It is argued, that this form of the spectral functions implies the quasi-splitting of the Fermi surface in the paramagnetic phase in the presence of strong ferromagnetic fluctuations.

TT 25.6 Di 11:00 TU H2053

Effects of Frustration in The Auxiliary-Fermion Approach to The 2D Quantum Heisenberg Model — •Jan Brinckmann and Peter Wölfle — Institut für Theorie der Kondensierten Materie, Uni Karlsruhe, D-76128 Karlsruhe

Recently we studied the nearest-neighbor quantum-antiferromagnetic Heisenberg model for spin 1/2 on a two-dimensional square lattice [1]. A self-consistent approach based on the auxiliary-fermion representation of spin operators yields a correlation length $\xi(T) \propto \exp(2\pi\rho_S/T)$ as well as signatures of short-range order in the dynamical structure factor, in good agreement with the literature.

In the present work we study the effect of quantum fluctuations caused by an additional next-nearest-neighbor coupling J_2 (J_1-J_2-model). In mean-field theory the order parameter is finite at the border $\eta = J_2/J_1 = 1/2$ between the Néel and collinear ground states, corresponding to a finite stiffness ρ_S at $T > 0$. Within the self-consistent approach, however, we find that strong fluctuations drive $\rho_S \to 0$ at $\eta = 1/2$. We also study the influence of the local Hilbert-space constraint on the auxiliary particles by comparing two variations of the approach: First the constraint is approximately replaced by a global one (as has been utilised in [1]), second the constraint is imposed exactly using a method proposed in [2].

[1] J. Brinckmann, P. Wölfle, Phys. Rev. **B 70**, in press (cond-mat/0405438)
[2] V. N. Popov, S. A. Fedotov, JETP **67**, 535 (1988)

TT 25.7 Di 11:15 TU H2053

Heat Transport in Almost Integrable Spin-Chains — •Peter Jung, Rolf Helmes, and Achim Rosch — Institute of Theoretical Physik, Cologne University, Zülpicher Str. 77, 50937 Köln, Germany

Integrable quantum spin chains are characterized by an infinite heat conductivity. We study the effect of small perturbations which destroy integrability. We evaluate a perturbation theory for $1/\kappa(T,\omega)$ using both exact diagonalization and a high temperature expansion which reconstructs the relevant correlation functions from its moments.

TT 25.8 Di 11:30 TU H2053

Excitation content of spectral functions in the 1D t-J model — •C. Lavalle[1], M. Arikawa[2], and A. Muramatsu[1] — [1]Institut für Theoretische Physik III, Universität Stuttgart, 70550 Stuttgart, Germany — [2]Bergische Universität Wuppertal, Fachbereich Physik, D-42097 Wuppertal, Germany

The excitation content of spectral functions of the 1D t-J model with nearest neighbor interactions is obtained from the Bethe Ansatz solution at the supersymmetric point and compared with quantum Monte Carlo (QMC) simulations based on the hybrid-loop algorithm [1]. We consider the one-particle spectrum as well as the dynamical spin and charge structure factors. The connection to the 1D supersymmetric t-J model with $1/r^2$ interaction will be explained and the extension to experimentally relevant values of J/t will be discussed on the basis of QMC results.

[1] C. Lavalle *et al.*, Phys. Rev. Lett. **90**, 216401 (2003).

TT 25.9 Di 11:45 TU H2053

Spin Gap in a Spiral Staircase Model — •Mikhail Kiselev[1], Dimitry Aristov[2], and Konstantin Kikoin[3] — [1]Insitut for Theoretical Physics and Astrophysics, Würzburg University, 97074 Würzburg, Germany — [2]Max-Planck-Institut für Festkörperforschung, Heisenbergstraße 1, 70569 Stuttgart, Germany — [3]Ben-Gurion University of the Negev, Beer-Sheva 84105, Israel

We investigate the formation of spin gap in one-dimensional models characterized by the groups with hidden symmetries. We introduce a new class of Hamiltonians for description of Spin Staircases - the spin systems intermediate between 2-leg ladders and S=1 spin chains. The spin exchange anisotropy along legs is described by the angle of spiral twist. The properties of a special case of Spin Rotator Chain (SRC) corresponding to a flat 1-leg ladder is considered by means of fermionization approach based on Jordan-Wigner transformation. The influence of dynamical hidden symmetries on the scaling properties of the spin gap is discussed.

TT 25.10 Di 12:00 TU H2053

Thermodynamics of a t–J chain with boundary impurities — •Guillaume Palacios and Holger Frahm — Institut für Theoretische Physik, Universität Hannover, D-30167 Hannover, Germany

We consider a supersymmetric t–J chain with integrable boundary impurities. Within the framework of the Quantum Inverse Scattering Method (QISM), these impurities are constructed by the combination of boundary fields with an integrable impurity [1]. The impurity site differs from the bulk chain by allowing double occupancy of the local orbitals. In addition to the boundary fields, that can be either a chemical potential or a magnetic field imposed at the ends of the chain, the model possesses two free parameters which allow to control the coupling between the Anderson-like impurity and the rest of the chain and the on-site interaction on the impurity site. It is of interest to mention that the latter can be tuned continuously without breaking the integrability of the model [2].

Starting from the Bethe Ansatz equations for the chain spectrum, our goal is to evaluate such impurities' contribution to thermodynamics quantities like magnetic susceptibilities or electronic densities.

[1] G. Bedürftig and H. Frahm, J. Phys A**32** (1999) 4585
[2] G. Bedürftig, F. H. L. Essler and H. Frahm, Nucl. Phys. B**489** (1997) 697

TT 25.11 Di 12:15 TU H2053

Quantum Creep and Variable Range Hopping of One-dimensional Interacting Electrons — •Thomas Nattermann, Serguei Malinin, and Bernd Rosenow — Institut für Theoretische Physik der Universität zu Köln, Zülpicher Str. 77, 50937 Köln

The variable range hopping results for non-interacting electrons of Mott and Shklovskii are generalized to 1D disordered charge density waves and Luttinger liquids using an instanton approach. Following a recent paper by Nattermann, Giamarchi and Le Doussal [Phys. Rev. Lett. **91**, 56603 (2003)] we calculate the quantum creep of charges at zero temperature and the linear conductivity at finite temperatures for these systems. The hopping conductivity for the short range interacting electrons acquires the same form as for non-interacting particles if the one-particle density of states is replaced by the compressibility. In the present paper we extend the calculation to dissipative systems and give a discussion of the physics after the particles materialize behind the tunneling barrier. It turns out that dissipation is crucial for tunneling to happen. Contrary to pure systems the new meta-stable state does not propagate through the system but is restricted to a region of the size of the tunneling region. This corresponds to the hopping of an integer number of charges over a finite distance. A global current results only if tunneling events fill the whole sample. We argue that rare events of extra low tunneling probability are not relevant for realistic systems of finite length. Finally we show that an additional Coulomb interaction only leads to small logarithmic corrections.

TT 25.12 Di 12:30 TU H2053

Nonlinear ac conductivity of disordered interacting 1d electrons — •Bernd Rosenow and Thomas Nattermann — Institut für Theoretische Physik, Universität zu Köln, D-50932 Germany

We consider low energy charge transport in one-dimensional (1d) electron systems with short range interactions under the influence of a random potential. For not too attractive interactions, such systems are insulators and the ac conductivity $\sigma_{\rm ac} \sim \omega^2 \ln(1/\omega)^2$ is described by a modified Mott-Halperin law [1]. At zero frequency, charge transport is only possible by the tunneling of charge carriers and the nonlinear dc conductivity is characterized by $I \sim \exp(-\sqrt{E_0/E})$ [2]. Combining RG and instanton methods, we calculate the nonlinear ac conductivity and discuss the crossover between the nonanalytic field dependence of the electric current at zero frequency and the linear ac conductivity at small electric fields and finite frequency [3].

[1] M. Fogler, Phys. Rev. Lett. **88**, 186402 (2002).
[2] T. Nattermann, T. Giamarchi, and P. Le Doussal, Phys. Rev. Lett. **91**, 056603 (2003).
[3] B. Rosenow and T. Nattermann, cond-mat/0408042.

TT 25.13 Di 12:45 TU H2053

Fermi Edge Singularities in the Mesoscopic Regime: From Rounded to Peaked Edge — •Martina Hentschel[1,2], Denis Ullmo[1], and Harold U. Baranger[1] — [1]Duke University, Durham NC 27708-0305 (USA) — [2]Universität Regensburg, D-93040 Regensburg

We study many-body effects associated with a sudden perturbation in a mesoscopic system, finding substantial differences from the bulk case. One example is the sudden, localized perturbation caused by an x-ray exciting a core electron into the conduction band. Here, Anderson orthogonality catastrophe (AOC) competes with a many-body effect caused by the interaction of the conduction electrons with the core hole. In the bulk, this produces deviations from the naively expected photoabsorption cross section in the form of a peaked or rounded edge. For a coherent system with chaotic dynamics, such as a nanoparticle or quantum dot, we use a random matrix model and find substantial changes: (1) the finite number of particles leads to an incomplete AOC, (2) the sample-to-sample fluctuations of the discrete energy levels produce a distribution of AOC overlaps, and (3) most importantly, the dipole matrix elements connecting the core and conduction electrons are substantially modified. One of our key results is that a photoabsorption cross section showing a rounded edge in the bulk will change to a slightly peaked edge on average as the system size is reduced to a mesoscopic (coherent) scale.

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