TT 30: CE: Low-dimensional Systems - Models 1

Time: Thursday 9:30–13:00 Location: H20

TT 30.1 Thu 9:30 H20

Cluster Spin-DMFT for Quantum Spin Ladders — •Mukul Laad[1,2] and Kai Philliph Schmidt[2] — [1]Institut für Theoretische Physik, RWTH Aachen D-52056, Aachen, Germany — [2]Lehrstuhl für Theoretische Physik I, Otto-Hahn-Strasse 4, TU Dortmund, 44221 Dortmund, Germany

We introduce a new cluster-DMFT scheme for quantum spin models, with a view to accessing short-ranged dynamical spin correlations underlying spin liquid behavior in low-dimensional frustrated systems. Here, we present concrete results for spin S=1/2 two-leg ladder systems, with and without additional frustrating interactions. These show valence-bond-solid ground (VBS) states with rich excitation spectra consisting of elementary triplons, two-triplon bound states, and multiparticle scattering continuua. A wealth of earlier theoretical results allow us to benchmark cluster spin-DMFT.

TT 30.2 Thu 9:45 H20

Orbital currents and SU(2) spin rotational symmetry breaking in doped two-leg Cu-O Hubbard ladders. — •Piotr Chudzinski[1], Marc Gabay[2], and Thierry Giamarchi[1] — [1]DPMC-MaNEP, University of Geneva, Geneva, Switzerland — [2]LPS, Université Paris-Sud 11, Orsay Cedex, France

In the weak-coupling limit, we study, as a function of doping, two leg ladders with a unit cell containing both Cu and O atoms. For purely repulsive interactions, using bosonization and a novel RG scheme, we find that in a broad region of the phase diagram, the ground state consists of a pattern of orbital currents (OCP) defined on the top of an incommensurate density wave. We focus on this OCP and check what kind of changes in the phase diagram one may expect due to SU(2) spin-rotational symmetry breaking. We also investigate a single impurity problem (incl. OCP): we discuss the nature of impurity backscattering, check if Kondo physics is at play. This enables us to show the influence of SU(2) symmetry breaking on conductivity. We estimate the value of gap opened due to the OCP and discuss magnetic properties of a new phase. Finally we investigate the influence, on the phase diagram, of other possible SU(2) breaking mechanisms. The motivation comes from the fact that two-leg ladder Hamiltonian can be used to describe broader class of materials of interest for example zig-zag carbon nanotubes.

TT 30.3 Thu 10:00 H20

Quantum spin chains of Temperley-Lieb type with periodic boundary conditions: spectra, multiplicities and finite temperature — •Britta Aufgebauer and Andreas Klümper — Universität Wuppertal

We determine the spectra of a class of quantum spin chains of Temperley-Lieb type by utilizing the concept of Temperley-Lieb equivalence with the XXZ chain as a reference system. For open boundaries the spectra of these models differ from the spectrum of the associated XXZ chain only in the multiplicities of the eigenvalues. The periodic case is rather different. Here we show how the spectrum is obtained sectorwise from the spectra of globally twisted XXZ chains. As a spin-off, we obtain a compact formula for the degeneracy of the momentum operator eigenvalues. Further the representation theoretical results allow for the study of the thermodynamics by establishing a ' TL-equivalence at finite temperature and finite field'.

TT 30.4 Thu 10:15 H20

Hierarchy of edge-locking effects in one-dimensional quantum lattice models. — •Masud Haque — MPI-PKS, Dresden

In one-dimensional lattices with open boundary conditions, I will present a hierarchy of edge-locking (or edge localization) effects. I will show versions of the phenomenon for three classic condensed-matter models: (1) the Bose-Hubbard model; (2) the spinless fermion model with nearest-neighbor repulsion; (3) the XXZ spin chain.

The edge-locking effects will be demonstrated through far-from-equilibrium dynamics and spectral characteristics far from the ground state.

TT 30.5 Thu 10:30 H20

Zero Temperature Phase Diagram of the 1D t-J Model with Density Matrix Renormalization Group — •Alexander Moreno[1], Alejandro Muramatsu[1], and Salvatore Manmana[2] — [1]Institut für Theoretische Physik III, Universität Stuttgart, Germany — [2]Institute of Theoretical Physics, Condensed Matter Theory, Lausanne, Switzerland

We study the ground state properties of the one-dimensional t-J model using the Density Matrix Renormalization Group (DMRG), obtaining its phase diagram. We found at low densities that the phase separation region is shifted to higher values of J/t in comparison to previous results [1,2,3]. We confirmed also the results of M. Nakamura et al. [4] who claim, in contrast to other studies [2,3], that a spin gap region is present at densities higher than 0.25. We show that on going from the LL to the spin-gap phase, electrons form pairs visible in real space. The density in real shows also an evidence of the existence of a very small region of the phase diagram where a four electron bound state can be found, as was first suggested by M. Ogata et al. [1]

[1] M. Ogata, M. U. Luchini, S. Sorella, and F. Assaad, Phys. Rev. Lett. **66**, 2388 (1991).

[2] C. Y. Chen and T. K. Lee, Phys. Rev. B. **47**, 17 (1993).

[3] C. S. Hellberg and E. J. Mele, Phys. Rev. B. **48**, 1 (1993).

[4] M. Nakamura, K. Nomura, and Kitazawa, Phys. Rev. Lett. **79**, 3214 (1997).

TT 30.6 Thu 10:45 H20

Renormalization group study of Luttinger liquids with boundaries — •Stephan Grap and Volker Meden — Inst. Theo. Physik A RWTH Aachen

We use Wilsons weak coupling "momentum" shell renormalization group method to show that two-particle interaction terms commonly neglected in bosonization of one-dimensional correlated electron systems with open boundaries are indeed irrelevant in the renormalization group sense. Our study provides a more solid ground for many investigations of Luttinger liquids with open boundaries.

15 min. break

TT 30.7 Thu 11:15 H20

Family of exactly solvable models with ultimate co-operative paramagnetic ground state — •Kai Phillip Schmidt[1] and Mukul Laad[1,2] — [1]Lehrstuhl für Theoretische Physik I, Otto-Hahn-Strasse 4, TU Dortmund, 44221 Dortmund, Germany — [2]Institut für Theoretische Physik, RWTH Aachen, 52056 Aachen, Germany

We present a family of two-dimensional frustrated quantum magnets solely based on pure nearest-neighbor Heisenberg interactions which can be solved quasi-exactly. All lattices are constructed in terms of frustrated quantum cages containing a chiral degree of freedom protected by frustration. The ground states of these models are dimer analogs of ultimate co-operative paramagnets and exhibit an extensive entropy at zero temperature. We discuss the unusual and extensively degenerate excitations in such phases. Implications for thermodynamic properties as well as for decoherence free quantum computation are discussed.

TT 30.8 Thu 11:30 H20

Spin Phonon Interactions in triangular Antiferromagnets — Andreas Kreisel and •Peter Kopietz — Institut für Theoretische Physik, Goethe Universität Frankfurt, Max-von-Laue Strasse 1, D-60438 Frankfurt (M), Germany

The triangular lattice antiferromagnet has been recognized a long time ago to be an ideal system to study the effect of quantum fluctuations and frustration in reduced dimensions. If the exchange couplings are spatially anisotropic as in the compound Cs_2CuCl_4, one can observe an ordered phase at very low temperatures. A standard experimental technique to explore the phase boundary is the measurement of the ultrasound attenuation. In order to describe this process theoretically, we consider the exchange striction coupling between magnons and phonons in the ordered phase of the triangular lattice antiferromagnet and calculate the renormalization of the phonon excitations due to the coupling to the magnons.

TT 30.9 Thu 11:45 H20

Spin-liquid and magnetic phases in the anisotropic triangular lattice: the case of κ-(ET)$_2$X — •Luca F. Tocchio[1], Alberto

Parola[2], Claudius Gros[1], and Federico Becca[3] — [1]Institute for Theoretical Physics, Goethe-University Frankfurt, Max-von-Laue-Straße 1, D-60438 Frankfurt am Main, Germany — [2]Dipartimento di Fisica e Matematica, Università dell'Insubria, Via Valleggio 11, I-22100 Como, Italy — [3]CNR-INFM-Democritos National Simulation Centre and International School for Advanced Studies (SISSA), Via Beirut 2, I-34151 Trieste, Italy

The two-dimensional Hubbard model on the anisotropic triangular lattice, with two different hopping amplitudes t and t', is relevant to describe the low-energy physics of κ-$(ET)_2X$, a family of organic salts. The ground-state properties of this model are studied by using Monte Carlo techniques, on the basis of a recent definition of backflow correlations for strongly-correlated lattice systems.

The results show that there is no magnetic order for reasonably large values of the electron-electron interaction U and frustrating ratio $t'/t = 0.85$, suitable to describe the non-magnetic compound with $X=Cu_2(CN)_3$. On the contrary, Néel order takes place for weaker frustrations, i.e., $t'/t \sim 0.4 - 0.6$, suitable for materials with $X=Cu_2(SCN)_2$, $Cu[N(CN)_2]Cl$, or $Cu[N(CN)_2]Br$.

TT 30.10 Thu 12:00 H20

Adapted continuous unitary transformation to treat systems with quasiparticles of finite lifetime — Tim Fischer, Sebastian Duffe, and •Götz S. Uhrig — Lehrstuhl Theoretische Physik I, TU Dortmund, 44221 Dortmund

Generic physical systems display excitations of finite life time. Famous examples are Landau's Fermi liquid or rotons in ^{4}He. Diagonalization by unitary transforms usually aims at stable excitation of infinite life time. Here we introduce an improved generator for continuous unitary transformations which is particularly suited to describe systems with unstable quasiparticles of finite life time. The general properties of this generator are derived and discussed. To illustrate this approach we investigate the asymmetric antiferromagnetic spin-$\frac{1}{2}$ Heisenberg ladder which allows for spontaneous triplon decay. The resonance behavior of the decaying triplon is shown explicitly.

TT 30.11 Thu 12:15 H20

Optimized basis in continuous unitary transformations for symmetry-broken groundstates — •Nils A. Drescher, Tim Fischer, and Götz S. Uhrig — Technische Universität Dortmund, Lehrstuhl für Theoretische Physik I, 44221 Dortmund, Germany

Continuous unitary transformations (CUTs) [1,2] are a method to systematically derive effective models for many-particle-systems of finite or infinite size. They allow us to separate Hilbert spaces of different numbers of quasiparticles. We use them to study dimerized, antiferromagnetic spin $\frac{1}{2}$ models. Our special interest is the quantum phase transition between spin liquid and long-range ordered phase with spontaneous staggered magnetization. To handle a spontaneously symmetry-broken groundstate with CUT, we modify the quasiparticle basis by introducing a continuous variation parameter. Even in the spin liquid phase, the optimal choice of this parameter leads to a significant gain of accuracy of magnetic properties. Results are shown for one and two dimensional systems.

[1] S. Dusuel and G.S. Uhrig, Journal of Physics A: Mathematics and General 37, 9275 (2004).

[2] C. Knetter, K.P. Schmidt, and G.S. Uhrig, Journal of Physics A: Mathematics and General 36(29), 7889 (2003).

TT 30.12 Thu 12:30 H20

Dynamical crossover in the fermionic Hubbard model — •Florian Goth and Fakher F. Assaad — Institut für Theoretische Physik und Astrophysik, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

We consider an implementation of the Diagrammatic Determinantal Quantum Monte-Carlo method on a Keldysh contour to study the realtime dependent evolution of the one-dimensional Hubbard model. The system is prepared in a thermal initial state, and the reaction to a sudden switching off of the Hubbard interaction is examined. The transition from an insulating thermal state at half-filling to metal like behaviour is studied on the basis of spin, charge and pairing correlation functions.

TT 30.13 Thu 12:45 H20

A new approach for the diagonalization of the Hubbard model using basis reordering — •Ralf Gamillscheg[1], Gundolf Haase[2], and Wolfgang von der Linden[1] — [1]Institute for Theoretical and Computational Physics, Graz University of Technology, Austria — [2]Institute for Mathematics and Scientific Computing, Karl-Franzens-University Graz, Austria

We present a new approach to obtain an effective Hamiltonian for many-particle systems which we call the Two-Subsystem Groundstate Approximation (TSGSA). The method was inspired by the so-called Automated Multilevel Substructuring Method (AMLS). Originally, it relies on subdividing the physical space into several regions. In these sub-systems the eigenproblem is solved, and the regions are combined in an adequate way. We developed a method to partition the state space of a many particle system in order to apply similar operations on the partitions. The tensorial structure of the Hamiltonians of these many-body systems make them even more suitable for this approach.

The method allows to break down the complexity of large many-body systems to the complexity of two spatial sub-systems having half the size. Considering the exponential size of the Hilbert space with respect to the system size this represents a huge advantage.

We will show applications of this method for ground-state calculations and for determining dynamical observables like the single-particle Green's function.