TT 16: Correlated Electrons: Low-dimensional Systems - Models 2

Time: Tuesday 9:30–13:15 Location: H 0104

TT 16.1 Tue 9:30 H 0104

The flat-band ferromagnetic transition as a Pauli-correlated percolation transition — •Mykola Maksymenko[1], Andreas Honecker[2], Roderich Moessner[3], Johannes Richter[4], and Oleg Derzhko[1] — [1]ICMP, 79011 Lviv, Ukraine — [2]ITP Georg-August-Universität Göttingen, 37077 Göttingen, Germany — [3]MPIPKS, 01187 Dresden, Germany — [4]Universität Magdeburg, Germany

It is known that flat bands yield a route to ferromagnetism in the Hubbard model, but the actual location and nature of the para-ferro transition remain unknown. We study the N-site Hubbard model on the 2D Tasaki lattice. For electron densities $n \leq \mathcal{N} = N/3$ many-electron ground states can be constructed from one-particle states localized in trapping cells. Occupation of neighboring traps may lead to an increase of energy due to on-site repulsion U. However, if electrons in neigboring traps are in a symmetric spin state, due to the Pauli principle on-site repulsion is not active, i.e. electrons can form a ferromagnetic cluster. This problem can be analyzed as a new Pauli-correlated site-percolation problem on the square lattice, where due to the Kramers degeneracy of independent ferromagnetic clusters different cluster coverings of electrons obtain different weights. We provide an exact solution for the corresponding 1D case and a numerical algorithm for the 2D case of the new percolation problem. In 2D the para-ferro transition takes place at concentration $p = n/\mathcal{N} = p_f = 0.66 \pm 0.01$ that is well above the threshold for the standard percolation $p_c \approx 0.59$. Moreover, there exists a region above p_f where ferromagnetism is unsaturated.

TT 16.2 Tue 9:45 H 0104

Accurate determination of the Gaussian transition in spin-1 chains with single-ion anisotropy — •Shijie Hu[1,2], Bruce Normand[1], Xiaoqun Wang[1], and Lu Yu[3] — [1]Department of Physics, Renmin University of China, Beijing 100872, China — [2]Institut fuer Theoretische Physik, Georg-August-Universitaet Goettingen, 37077 Goettingen, Germany — [3]Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China

The Gaussian transition in the spin-one Heisenberg chain with single-ion anisotropy is extremely difficult to treat, both analytically and numerically. We introduce an improved DMRG procedure with strict error control, which we use to access very large systems. By considering the bulk entropy, we determine the Gaussian transition point to 4-digit accuracy, $D_c/J = 0.96845(8)$, resolving a long-standing debate in quantum magnetism. With this value, we obtain high-precision data for the critical behavior of quantities including the ground-state energy, gap, and transverse string-order parameter, and for the critical exponent, $\nu = 1.472(2)$. Applying our improved technique at $J_z = 0.5$ highlights essential differences in critical behavior along the Gaussian transition line.

TT 16.3 Tue 10:00 H 0104

Spontaneous Quasiparticle Decay in Low-Dimensional Quantum Spin Systems — •Tim Fischer and Götz S. Uhrig — Theoretische Physik I, Technische Universität Dortmund, 44221 Dortmund

In sufficiently dimerized quantum antiferromagnets the elementary excitations are gapped spin $S = 1$ triplon quasiparticles. Although these triplons are protected by a gap at low energies they may decay spontaneously at higher energies where the one-triplon dispersion merges with the two-triplon continuum. The decay implies the breakdown of the quasiparticle picture. No quantitative description by a Lorentzian resonance is possible.

We characterize the decay for low-dimensional quantum antiferromagnets in detail. In particular, three qualitatively different scenarios are identified depending on the one-triplon dispersion and the two-triplon interaction.

Based on the theoretical concepts we analyse the inelastic neutron scattering (INS) results for IPA-$CuCl_3$ [1]. Starting from the microscopic model obtained by adapted continuous unitary transformations (CUTs) [2] we provide a quantitative description of the decay measured in IPA-$CuCl_3$ by INS.

[1] T. Masuda *et al.* (2006) PRL **96** 047210
[2] T. Fischer, S. Duffe and G. S. Uhrig (2011) EPL **96** 47001

TT 16.4 Tue 10:15 H 0104

Channel-decomposed renormalization group equations for the vertex in a superconductor — •Andreas Eberlein and Walter Metzner — Max-Planck-Institut für Festkörperforschung, Heisenbergstr. 1, D-70569 Stuttgart

We study ground state properties of the attractive Hubbard model at weak coupling with the aim of finding an efficient description of the effective Nambu two-particle vertex in a singlet superconductor. We decompose the vertex into a sum of interaction channels, each capturing a particular singular dependence on external momenta and frequencies. Using the functional renormalization group, we derive flow equations for the interaction channels on one-loop level. We compute the frequency dependence of the self-energy as well as the momentum and frequency dependence of the two-particle vertex. Our results for the impact of fluctuations on the superconducting gap are in good agreement with the literature. This indicates that the channel-decomposition scheme indeed captures the singular momentum and frequency dependence of the vertex.

TT 16.5 Tue 10:30 H 0104

Functional RG for the Anderson Impurity Model — •Michael Kinza[1], Jutta Ortloff[2], Manuel Schmidt[1], and Carsten Honerkamp[1] — [1]Institut für Theoretische Festkörperphysik, RWTH Aachen University, Deutschland — [2]Insititut für Theoretische Physik und Astrophysik, Universität Würzburg, Deutschland

We present a functional Renormalization Group (fRG) approach to the Anderson Impurity model at finite temperatures. Starting with the exact spectral function and interaction vertex of a small system ('core') containing a correlated site, we switch on the hybridization with a non-interacting bath in the RG-flow and calculate spectra of the correlated site. We discuss the emergence of the Kondo-scale in different truncation-levels of the RG-flow-equations and for different choices of the core. Therefore the effective mass and the linear conductance as function of temperature and magnetic field is calculated. Furthermore we discuss an extension of our approach that can describe Anderson-impurities in helical liquids.

TT 16.6 Tue 10:45 H 0104

A renormalization group approach to time dependent transport through correlated quantum dots — •Dante Marvin Kennes[1], Severin Georg Jakobs[1], Christoph Karrasch[2], and Volker Meden[1] — [1]Institut für Theorie der Statistischen Physik, RWTH Aachen University and JARA-Fundamentals of Future Information Technology, 52056 Aachen, Germany — [2]Department of Physics, University of California, Berkeley, California 95720, USA

We introduce a real time version of the functional renormalization group which allows to study correlation effects on nonequilibrium transport through quantum dots. Our method is equally capable to address (i) the relaxation out of a nonequilibrium initial state into a steady state driven by a bias voltage and (ii) the dynamics governed by an explicitly time-dependent Hamiltonian. All time regimes from transient to asymptotic can be tackled; the only approximation is the consistent truncation of the flow equations at a given order. As an application we investigate the relaxation dynamics of the interacting resonant level model which describes a fermionic quantum dot dominated by charge fluctuations. Moreover, we study decoherence and relaxation phenomena within the ohmic spin-boson model by mapping the latter to the interacting resonant level model.

TT 16.7 Tue 11:00 H 0104

A New View of the Mott-Hubbard Transition: Renormalization of the Fermi-Surface Topology — •Luca Fausto Tocchio[1], Federico Becca[2], and Claudius Gros[1] — [1]Institute of Theoretical Physics, Goethe University, Frankfurt am Main, Germany — [2]International School for Advanced Studies (SISSA), Trieste, Italy

We present the renormalization of the (underlying) Fermi-surface topology in the Hubbard model on a square lattice with frustrating hopping, that is relevant for the physics of high-temperature superconductors. With the help of novel high precision variational tools, including Jastrow factors and backflow correlations, we show that the Fermi surface renormalizes to perfect nesting at the interaction-driven Mott-Hubbard transition and in the large interaction limit. Moreover, we present new results for the density-driven Mott-Hubbard transition,

investigating the Fermi-surface renormalization flow as a function of doping, where the renormalization occurs only when the half-filled case is insulating. Finally, we show also that Fermi surface renormalization is associated to a strong crossover at finite doping for the critical U corresponding to the Mott-Hubbard transition.

15 min. break.

TT 16.8 Tue 11:30 H 0104

Charge Fractionalization on Quantum Hall Edges — •Mats Horsdal[1], Marianne Rypestøl[2], Hans Hansson[3], and Jon Magne Leinaas[2] — [1]Institute for Theoretical Physics, University of Leipzig, D-04009 Leipzig, Germany — [2]Department of Physics, University of Oslo, N-0316 Oslo, Norway — [3]Department of Physics, Stockholm University, AlbaNova University Center, SE-106 91 Stockholm, Sweden

I will discuss the propagation and fractionalization of localized charges on the edges of quantum Hall bars of variable widths, where interactions between the edges give rise to Luttinger liquid behavior with a non-trivial interaction parameter g. I will focus in particular on the separation of an initial charge pulse into a sharply defined front charge and a broader tail. The front pulse describes an adiabatically dressed electron which carries a non-integer charge, which is $\sqrt{g}$ times the electron charge. I will discuss how the presence of this fractional charge can, in principle, be detected through measurements of the noise in the current created by tunneling of electrons into the system. The results are illustrated by numerical simulations of a simplified model of the Hall bar.

TT 16.9 Tue 11:45 H 0104

Valence bond crystal and possible analog of a supersolid in a t_{2g} orbital model — •Fabien Trousselet[1], Arnaud Ralko[2], and Andrzej M. Oleś[1,3] — [1]Max Planck Institut für Festkörperforschung, Stuttgart, Germany — [2]Institut Néel, Grenoble, France — [3]Marian Smoluchowski Institute of Physics (Jagiellonian University), Kraków, Poland

We investigate an orbital model for localized t_{2g} electrons on the triangular lattice, and interacting via exchange processes between nearest neighbors. The Hamiltonian interpolates between two limits where either superexchange or direct-exchange predominates; it is relevant to some titanate compounds (e.g. $NaTiO_2$), in a situation where spins are polarized by e.g. a large magnetic field.

Within this frame, we analyze the ground state properties of the model, by exact diagonalizations and the use of effective Hamiltonians. When superexchange interactions dominate, they favor orbital singlets on nearest neighbor bonds, which results in a dimerized phase. We characterize this phase, with help of an effective quantum dimer model, as a valence bond crystal with a large unit cell. In the opposite regime of dominant direct-exchange, we find another exotic phase, which can be seen as an orbital analog of a supersolid, where long-ranged orbital order coexists with dynamics induced by perturbing kinetic terms.

TT 16.10 Tue 12:00 H 0104

Phase diagram of the bilinear-biquadratic-bicubic spin 3/2 chain — •Stephan Rachel[1] and Andreas M. Läuchli[2] — [1]Department of Physics, Yale University, New Haven, CT 06520, USA — [2]Institut für Theoretische Physik, Universität Innsbruck, A-6020 Innsbruck, Austria

The most general spin 3/2 chain with SU(2) invariant nearest neighbor interactions is investigated. Using exact diagonalization and density matrix renormalization group the corresponding phase diagram is explored. It hosts a plethora of phases. Besides the critical and ferromagnetic phases containing the usual Heisenberg models, we find dimerized, partial ferromagnetic, and a period-4 phase with enhanced SU(4) symmetry. Furthermore, in the vicinity of the antiferromagnetic Heisenberg point we identify a period-6 phase.

TT 16.11 Tue 12:15 H 0104

Application of Valence Bond States to Nano-Sized Spin Clusters — •Maren Gysler, Nikolaos P. Konstantinidis, and Oliver Waldmann — Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany

The importance of understanding correlations in nano-sized spin clusters has risen in recent years with the availability of magnetic systems such as single-molecule magnets and spins attached to surfaces, which consist of a dozen or so antiferromagnetically coupled metal centers with potentially large spin lengths. Strong correlations between neighboring spins are difficult to single out when the familiar product basis or irreducible tensor operator techniques are used. The valence bond states can be used in an efficient way to study ground-state correlations of the clusters as strong short range quantum correlations can naturally be captured by them.

In this talk we will present a general method to use valence bond states as an alternative basis for the antiferromagnetic Heisenberg Hamiltonian of spin clusters with arbitrary exchange coupling strength, spins, and coupling topologies. The complications due to the overcompletness and non-orthogonality are circumvented by diagonalizing the Hamilton matrix in the spin coupled basis. Subsequently the spin coupled states are expressed in what we call the physical valence bond states. The developed method will be applied to special examples of spin clusters for illustration.

TT 16.12 Tue 12:30 H 0104

Entanglement of hard-core bosons in bipartite lattices — •Raoul Dillenschneider, Xue-Feng Zhang, and Sebastian Eggert — Physics Dept. and Res. Center OPTIMAS, Univ. of Kaiserslautern, 67663 Kaiserslautern, Germany.

The entanglement of hard-core bosons in square and honeycomb lattices with Coulomb interactions is estimated by means of quantum Monte Carlo simulations and spin-wave analysis. The particular U(1)-invariant form of the concurrence is used to establish a connection with observables such as density and superfluid density. For specific regimes the concurrence is expressed as a combination of boson density and superfluid density. Symmetry breaking is demonstrated characterizing entanglement patterns.

TT 16.13 Tue 12:45 H 0104

The effect of a local perturbation in a fermionic ladder — Sam Carr[1], •Boris Narozhny[1], and Alexander Nersesyan[2,3,4] — [1]Institut für Theorie der Kondensierten Materie and DFG Center for Functional Nanostructures, Karlsruher Institut für Technologie, 76128 Karlsruhe, Germany — [2]The Abdus Salam International Centre for Theoretical Physics, 34100, Trieste, Italy — [3]The Andronikashvili Institute of Physics, 0177, Tbilisi, Georgia — [4]Ilia State University, Institute of Theoretical Physics, 0162, Tbilisi, Georgia

We study the effect of a local external potential on a system of two parallel nanowires placed close to each other. For single channel, spin-polarized nanowires with repulsive interaction we find that transport properties of the system are highly sensitive to the transverse gradient of the perturbation: the asymmetric part completely reflects the electrons leading to vanishing conductance at zero temperature, while the flat potential remains transparent. We envisage a possible application of this unusual property in the sensitive measurement of local potential field gradients. We then further extend our results to the case of nanowires in the absence of the polarized field.

TT 16.14 Tue 13:00 H 0104

Constraints on measurement-based quantum computation in effective cluster states — Daniel Klagges and •Kai Phillip Schmidt — Lehrstuhl für Theoretische Physik I, TU Dortmund, Germany

The aim of this work is to study the physical properties of a one-way quantum computer in an effective low-energy cluster state. We calculate the optimal working conditions as a function of the temperature and of the system parameters. The central result of our work is that any effective cluster state implemented in a perturbative framework is fragile against special kinds of external perturbations. Qualitative aspects of our work are important for any implementation of effective low-energy models containing strong multi-site interactions.