TT 62: CE: Low-dimensional Systems - Models 2

Time: Friday 10:30–13:15 Location: HSZ 105

TT 62.1 Fri 10:30 HSZ 105

Entanglement Hamiltonian of quantum spin systems — •Vincenzo Alba, Masud Haque, and Andreas Lauchli — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

We investigate the 'entanglement hamiltonian' of one-dimensional quantum spin systems, such as the XXZ chain and Heisenberg ladders. We analyze entanglement spectra obtained using exact diagonalization and DMRG. We provide physical insight into the main features of the spectra through perturbative calculations. In particular we show that the physics at the block boundaries plays a crucial role in determining the form of the entanglement spectrum and hence of the entanglement Hamiltonian.

TT 62.2 Fri 10:45 HSZ 105

Robustness of the toric code in an arbitrary magnetic field — Sébastien Dusuel[1], •Michael Kamfor[2], Román Orús[3], Kai Phillip Schmidt[2], and Julien Vidal[1] — [1]Lycée Saint-Louis, 44 Boulevard Saint-Michel, 75006 Paris, France — [2]Lehrstuhl für Theoretische Physik I, Otto-Hahn-Str. 4, TU Dortmund, 44221 Dortmund, Germany — [3]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

We investigate the stability of the topological phase in the toric code model in the presence of an arbitrary uniform magnetic field by means of variational approach (iPEPS) and high order series expansion (PCUT). It is found that when this perturbation is strong enough, the anyonic gap closes and the system undergoes a phase transition whose nature depends on the field orientation. When this transition is of second order, it is in the Ising universality class except for a special line on which the critical exponent, driving the closure of the gap, varies continuously

TT 62.3 Fri 11:00 HSZ 105

Interaction-induced Fermi-surface renormalization in frustrated Hubbard models — •Luca F. Tocchio[1], Federico Becca[2], and Claudius Gros[1] — [1]Institute for Theoretical Physics, Frankfurt University, Max-von-Laue-Straße 1, D-60438 Frankfurt a.M., Germany — [2]CNR-IOM-Democritos National Simulation Centre and International School for Advanced Studies (SISSA), Via Bonomea 265, I-34136, Trieste, Italy

We investigate the nature of the interaction-driven Mott-Hubbard transition for frustrated Hubbard models, using a variational Monte Carlo approach including a distance-dependent Jastrow factor and a novel-type of holon-doublon correlation, the so-called backflow correlations. They allow to treat the doublon-holon excitons correctly in the large-U limit and for an improved understanding of the Fermi-surface renormalization close to the Mott-Hubbard transition. Indeed, we find that the Fermi surface renormalizes to perfect nesting right at the Mott-Hubbard transition in the insulating state, with a first-order reorganization when crossing the transition into the metallic state. This result may potentially change our view of the Mott-Hubbard transition in finite dimensions, since it seems to be qualitatively different from its infinite-dimension analogon.

TT 62.4 Fri 11:15 HSZ 105

Excitations and spectral densities of the one-dimensional Ising model in a field — •Marc Daniel Schulz and Kai Phillip Schmidt — Lehrstuhl für Theoretische Physik I, TU Dortmund, 44221 Dortmund, Germany

The one-dimensional quantum Ising model in a transverse field is a well-studied model in theoretical physics, which was solved exactly more than 40 years ago. 30 years ago, the prediction of the existence of a certain number of bound states at the critical point in the presence of an infinitesimal longitudinal field was made by integrable field theory. Here we study the excitation spectra and the spectral densities of the Ising model in a transverse and a longitudinal field, containing the physics of free and confined quasi-particles. To this end, we derive effective low-energy models for the low- and for the high-field case by means of perturbative and graph-based continuous unitary transformations. Our calculations are expected to be relevant for recent inelastic neutron scattering measurements on the quasi one-dimensional compound $CoNb_2O_6$ which is believed to be effectively described by an one-dimensional Ising model in a field.

TT 62.5 Fri 11:30 HSZ 105

Spin Correlations and Excitations in Small Antiferromagnetic Clusters — •Maren Gysler, Nikolaos P. Konstantinidis, and Oliver Waldmann — Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany

The importance of understanding correlations in small 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. An efficient way to study ground-state correlations and low-energy spectra of small clusters is the use of the valence bond basis, which defines a natural framework where strong short range correlations can directly be incorporated in the Hilbert space basis. Using the different bases we investigate the spin correlations and excitations in a number of generic spin systems, with particular emphasis on understanding the influence of the topology of the exchange couplings. Typical theoretical models would include the even and odd short chains with large spins and small wheels.

15 min. break

TT 62.6 Fri 12:00 HSZ 105

Real-Space Renormalization Yields Finite Correlations — Thomas Barthel, •Martin Kliesch, and Jens Eisert — Potsdam University

Real-space renormalization approaches for quantum lattice systems generate certain hierarchical classes of states that are subsumed by the multiscale entanglement renormalization Ansatz (MERA). It is shown that, with the exception of one spatial dimension, MERA states are actually states with finite correlations, i.e., projected entangled pair states (PEPS) with a bond dimension independent of the system size [1]. Hence, real-space renormalization generates states which can be encoded with local effective degrees of freedom, and MERA states form an efficiently contractible class of PEPS that obey the area law for the entanglement entropy.

[1] Phys. Rev. Lett. 105, 010502 (2010)

TT 62.7 Fri 12:15 HSZ 105

The 1-D t-J model in and out of equilibrium — •Alexander Moreno and Alejandro Muramatsu — Institut für Theoretische Physik III, Universität Stuttgart, Germany

On the basis of the density matrix renormalization group (DMRG) we study the ground-state phase diagram of the model and the excitation content of each phase. As a first step, we determine the transition lines between a repulsive Luttinger liquid (LL) phase, an attractive LL phase, a spin-gap (Luther-Emery - LE) phase, and phase-separation. In particular, we resolve a controversy about the extension of the LE phase, and show evidence for real-space pairing deep in that phase. By switching an electric field after the creation of an electron in the system, we aim at identifying the charge of the fractionalized elementary excitations that result from the electron. A previous quantum Monte Carlo simulation of the model [1] revealed that the spectral content of the electron addition spectrum could be accounted for by a spinon, a holon, and an antiholon, as in the supersymmetric $1/r^2$ t-J model [2]. These excitations have respectively $S = 1/2$, $Q = 0$; $S = 0$, $Q = -e$; and $S = 0$, $Q = 2e$, where e is the charge of the electron.

[1] C. Lavalle, M. Arikawa, S. Capponi, F. F. Assaad, and A. Muramatsu, Phys. Rev. Lett. **90**, 216401 (2003).
[2] M. Arikawa, Y. Saiga, and Y. Kuramoto, Phys. Rev. Lett. **86**, 3096 (2001).

TT 62.8 Fri 12:30 HSZ 105

Relaxation dynamics of an exactly solvable electron-phonon model — •Dante Marvin Kennes and Volker Meden — Institut für Theoretische Physik A and JARA-Fundamentals of Future Information Technology, RWTH Aachen University, 52056 Aachen, Germany

We address the question whether observables of an exactly solvable

model of electrons coupled to (optical) phonons relax into large time stationary state values and investigate if the asymptotic expectation values can be computed using a stationary density matrix. A sudden quench of the electron-phonon coupling, starting from the noninteracting canonical equilibrium at temperature T in the electron as well as in the phonon subsystems is considered as well as a setup being given by the product of the phonon vacuum and the filled Fermi sea supplemented by a highly excited additional electron. In accordance with earlier studies of such type of models we find that expectation values which become stationary can be described by the density matrix of a generalized Gibbs ensemble which differs from that of a canonical ensemble.

TT 62.9 Fri 12:45 HSZ 105

Local density of states of a quarter-filled 1D Mott insulator with a boundary — •Dirk Schuricht — Institut für Theorie der Statistischen Physik, RWTH Aachen — JARA-Fundamentals of Future Information Technology

We determine the local density of states (LDOS) of a quarter-filled one-dimensional Mott insulator in the presence of a strong impurity potential, which is modeled by a boundary. To this end we calculate the Green function in the low-energy limit using field theory techniques. The Fourier transform of the LDOS shows signatures of a pinning of the spin density wave at the imprity as well as several dispersing features at frequencies above the charge gap, which can be interpreted as propagating spin and charge degrees of freedom. Finally, we discuss the effect of bound states localized at the impurity.

TT 62.10 Fri 13:00 HSZ 105

Correlation effects in quantum spin Hall states: a Quantum Monte Carlo study — Martin Hohenadler, •Thomas C. Lang, and Fakher F. Assaad — Institut für Theoretische Physik und Astrophysik, Universität Würzburg, Germany

We consider a quantum spin hall insulator as realized by the Kane-Mele model with spin orbit coupling λ supplemented by a Hubbard U term. On the basis of projective auxiliary field quantum Monte Carlo simulations on lattice sizes up to 12×12, we map out the magnetic phase diagram. Beyond a critical value of $U > U_c$ the quantum spin Hall insulating state is unstable towards magnetic ordering. At $U < U_c$ we study the spin, charge and single particle dyanmics of the helical edge state by retaining the Hubbard interactions only on the edge of a ribbon. As U_c is approached we observe a substantial depletion of low-lying spectral weight in the dynamical charge structure factor, and a robust signature of the helical edge state in the single particle spectral function.