TT 25: Correlated Electrons: Low-Dimensional Systems - Models 3

Time: Tuesday 9:30–13:15 Location: H9

TT 25.1 Tue 9:30 H9

Interacting Fröhlich and Holstein bipolarons — •Monodeep Chakraborty[1], Masaki Tezuka[2], and Byung Il Min[1] — [1]Department of Physics, POSTECH, Pohang, 790-784, Korea — [2]Department of Physics, Kyoto University, Kyoto 606-8502, Japan

Polarons and bipolarons have been long-term subjects of interest in many areas of condensed matter. We have investigated the bipolaron-bipolaron interaction for the Holstein-Hubbard (HH) and the Fröhlich-Hubbard(FH) model on a discrete one-dimensional (1D) lattice. We have generated a variational space by repeated application of our chosen Hamiltonian on a initial state and then used conjugate-gradient technique to obtain the ground state energy as well as the wave-function for a few electron (two, four and six) and phonon system. The HH model has also been studied with density-matrix renormalization group (DMRG). Both methods lead to the same conclusion that there exists no bipolaron-bipolaron attraction in the HH model. However, we obtain clear cut bipolaron-bipolaron attraction within the Fröhlich paradigm above a critical electron-phonon coupling forming the bipolaron cluster. The bipolaron cluster can survive in spite of the Hubbard-U effect up to a finite U and then separates into individual bipolarons or polarons. The bipolaron-bipolaron attraction could be a possible mechanism of the phase separation in many condensed matter systems with the strong electron-phonon interaction.

TT 25.2 Tue 9:45 H9

Non-equilibrium dynamics of the Kondo cloud following quenches in the Resonant Level Model — •Shreyoshi Ghosh, Pedro Ribeiro, and Masud Haque — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

We study the non-equilibrium dynamics of lattice realizations of the Resonant Level Model. In equilibrium, the conduction electrons form a screening cloud around the impurity site. This impurity screening cloud has been the subject of longstanding fascination, especially in the Kondo model, from which the resonant level model emerges in the Toulouse limit. We present results on the time evolution of the spatial structure of the impurity screening cloud, after local and global quenches of system parameters.

TT 25.3 Tue 10:00 H9

Breakdown of flat bands in highly-frustrated spin systems — •Michael Powalski[1], Kris Coester[1], Roderich Moessner[2], and Kai Phillip Schmidt[1] — [1]Lehrstuhl für Theoretische Physik I, TU Dortmund, Germany — [2]Max Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany

In several highly-frustrated spin systems the low-energy excitation band is known to be exactly flat up to a certain perturbative order. One important example is the fully-frustrated transverse field Ising model on the kagome lattice. Its lowest one-particle band is extremely flat becoming dispersive only in order eight perturbation theory in the high-field limit. This behaviour can be traced back to the existence of a local mode being an exact eigenstate up to seventh order.

Here we use high-order series expansions to investigate the occurrence and the breakdown of flat bands in geometrically frustrated systems. It is shown that the breakdown of such flat bands is connected to quantum fluctuations which do not interfere destructively. This can be understood intuitively via the used linked cluster expansion.

TT 25.4 Tue 10:15 H9

Renyi entropies of classical loop gases and string nets — •Mascha Baedorf, Maria Hermanns, and Simon Trebst — Universitaet zu Koeln, Germany

Since the seminal work of Shannon the concept of entropy is closely connected to the information content of a many-body state. This link has been widely employed in recent years to characterize quantum many-body states whose defining characteristic eludes a description in terms of correlation functions and a local order parameter. Probably the most prominent example of the latter are topologically ordered states, for which the so-called topological entanglement entropy provides an unambiguous identification and partial characterization of the non-local topological order. Here we discuss the classical analog of the Renyi entropy and via extensive numerical simulations demonstrate its ability to positively identify topological order in classical loop gas and possibly string net states.

TT 25.5 Tue 10:30 H9

Tunable Superconductivity with Ultracold Polar Molecules and Enhanced Superconducting Phases in dipolar $t-J_\perp$ chains — •Salvatore R. Manmana[1,2], Kaden R.A. Hazzard[2], Gang Chen[2], Alexey V. Gorshkov[3], and Ana Maria Rey[2] — [1]Institut für Theoretische Physik, Universität Göttingen, Germany — [2]JILA, University of Colorado and NIST, and Department of Physics, CU Boulder, USA — [3]Institute for Quantum Information & Matter, Caltech, Pasadena, California, USA

By selecting two dressed rotational states of ultracold polar molecules in an optical lattice, we obtain a highly tunable generalization of the t-J model, which we refer to as the t-J-V-W model. In addition to XXZ spin exchange, the model features density-density interactions and density-spin interactions, all of them $\sim 1/r^3$. Full control of all interaction parameters in both magnitude and sign can be achieved independently of each other and of the tunneling. We apply the density matrix renormalization group method to obtain the 1D phase diagram in the case of nearest neighbor hopping and long-range transverse spin-exchange $J_\perp$. The anisotropy in the spin-exchange and the long-range nature of the interactions lead to an enhanced superconducting phase. We discuss that the long-range interactions despite the presence of a gap lead to an algebraically decaying contribution to correlation functions.

TT 25.6 Tue 10:45 H9

Bosonic Fractional Quantum Hall States in Rotating Optical Lattices: Projective Symmetry Group Analysis — •Tanja Duric and Achilleas Lazarides — Max Planck Institute for the Physics of Complex Systems, Noethnitzer Str. 38, 01187 Dresden, Germany

We study incompressible ground states of bosons in a two-dimensional rotating square optical lattice. The system can be described by the Bose-Hubbard model in an effective uniform magnetic field present due to the lattice rotation. To study ground states of the system, we map it to a frustrated spin model, followed by Schwinger boson mean field theory and projective symmetry group analysis. Using symmetry analysis we identify bosonic fractional quantum Hall states, predicted for bosonic atoms in rotating optical lattices, with possible stable gapped spin liquid states within the Schwinger boson formalism. In particular, our results indicate that previously obtained fractional quantum Hall states induced by the lattice potential, and with no counterpart in the continuum, correspond to pi-flux spin liquid states of the frustrated spin model.

15 min. break

Topical Talk TT 25.7 Tue 11:15 H9

One-dimensional fermion systems beyond the Luttinger Liquid paradigm — •Thomas L. Schmidt[1,2], Adilet Imambekov[3], and Leonid I. Glazman[1] — [1]Department of Physics, Yale University, New Haven, Connecticut 06520, USA — [2]Department of Physics, University of Basel, CH-4056 Basel, Switzerland — [3]Department of Physics and Astronomy, Rice University, Houston, Texas 77005, USA

For many years, Luttinger liquid theory has served as a useful paradigm for the description of 1D quantum fluids in the limit of low energies. This theory is based on a linearization of the dispersion relation of the particles constituting the fluid. In this talk, I will review recent progress in understanding 1D fermion systems beyond the low-energy limit, where the nonlinearity of the dispersion relation becomes essential. I will present results for the dynamic correlation functions of spinless and spinful fermion systems, and discuss the fate of spin-charge separation, one of the hallmarks of the linear Luttinger liquid theory, beyond the low-energy limit.

TT 25.8 Tue 11:45 H9

Impurity effects in frustrated magnets with subextensive degeneracies — •Stefan Bittihn and Simon Trebst — Universität zu Köln, Germany

We consider the effects of local impurities in frustrated honeycomb-lattice antiferromagnets, which exhibit large but nonextensive ground-state degeneracies. In the absence of impurities magnetic order is induced via a thermal order-by-disorder mechanism. In the presence of impurities this entropic selection of states is put into competition with an energetic selection of states favored by the impurities, a more conventional order by quenched disorder mechanism. We characterize the latter via extensive numerical simulations on large-scale lattices.

TT 25.9 Tue 12:00 H9

Expansion dynamics of interacting bosons in homogeneous lattices — •Jens Philipp Ronzheimer[1,2], Michael Schreiber[1,2], Simon Braun[1,2], Sean S. Hodgman[1,2], Stephan Langer[2,3], Ian P. McCulloch[4], Fabian Heidrich-Meisner[5,2], Immanuel Bloch[1,2], and Ulrich Schneider[1,2] — [1]LMU München — [2]MPQ Garching — [3]University of Pittsburgh, USA — [4]University of Queensland, Brisbane, Australia — [5]Universität Erlangen-Nürnberg, Erlangen

We study out-of-equilibrium dynamics and transport properties of interacting many-body systems using ultracold atoms in optical lattices. Specifically, we experimentally and numerically investigate the expansion dynamics of initially localized bosons in homogeneous 1D and 2D Hubbard systems. We find that the fastest, ballistic expansions occur in the integrable limits of the system. In 1D, these are both the non-interacting and the strongly-interacting limits where the system enters into the hard-core boson regime. Any deviation from these limits, either through finite interactions or the admixture of double occupancies in the initial state, significantly slows down the expansion. In 2D, the strongly interacting limit is fundamentally different. The system expands ballistically only in the non-interacting case, while all interactions lead to strongly diffusive behavior. This is in full analogy to previous experiments with interacting fermions. By controlling the tunneling along individual lattice axes, we can gradually change the dimensionality of the system from 1D to 2D. In the strongly interacting case, we observe how the initially ballistic dynamics in a 1D system turn diffusive when additional degrees of freedom become available.

TT 25.10 Tue 12:15 H9

The Role of Local and Non-Local Conserved Quantities in the Thermalization of Closed Quantum Systems — •Nikolaos P. Konstantinidis and Jesko Sirker — Fachbereich Physik und Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

We investigate thermalization after a sudden quench for antiferromagnetic Heisenberg models on finite rings, with extrapolation of the results to the thermodynamic limit. We show that in the non-integrable case, which results from the inclusion of next-nearest neighbor interactions, only local conservation laws are important for the thermalization of local quantities, while the contribution of non-local operators vanishes exponentially with system size. The equilibrated system in the thermodynamic limit is thus described by a canonical ensemble. We also examine how in the integrable case the additional local but longer-range conserved quantities affect thermalization.

TT 25.11 Tue 12:30 H9

The eigenstate thermalization hypothesis near integrable points — •Wouter Beugeling, Masud Haque, and Roderich Moessner — Max Planck Institute for the Physics of Complex Systems (MPI-PKS), Dresden, Germany

In the field of nonequilibrium quantum dynamics, the issue of thermalization in isolated systems has been the topic of intense recent interest. The eigenstate thermalization hypothesis (ETH) has been proposed as a mechanism for the thermalization of nonintegrable systems. According to the ETH, the expectation values of typical physical observables in eigenstates vary smoothly as a function of the corresponding eigenenergies.

We discuss systems that can be tuned towards and away from integrability by the variation of parameters in the Hamiltonian. We present results on whether and how the ETH progressively breaks down as we approach an integrable point. We also address the role played by the choice of physical observable.

TT 25.12 Tue 12:45 H9

Exact description of the magnetoelectric effect in the spin-1/2 XXZ-chain with Dzyaloshinskii-Moriya interaction — •Vadim Ohanyan[1], Andreas Kluemper[2], and Michael Brockmann[2,3] — [1]Yerevan State University, 1 Alex Manoogian 0025 Yerevan, Armenia — [2]Bergische Universitaet Wuppertal, Gauss str.20, D-42119, Wuppertal, Germany — [3]University of Amsterdam, Science Park 904, 1098 XH Amsterdam, Netherlands

We considered the S=1/2 XXZ-chain with DM-term in the context of magnetoelectric effect realized by means of Katsura-Nagaosa-Baladsky(KNB) mechanism, which connects the local polarization with the cross product of two neighboring spin. Considering, thus, the DM-term as an interaction between local polarization and external electric field, we apply the quantum transfer matrix(QTM) and non-linear integral equation(NLIE) technique for exact description of the mutual influence of magnetic and dielectric properties at finite temperatures, known as the magnetoelectric effect. We obtain the exact plots of polarization(magnetization) dependence on magnetic(electric) filed as well as temperature dependence of the magnetoelectric tensor. The results, particularly, show several possible regimes of polarization, linear, square-root, quadratic and some combination of them. The switching between different regimes can be easily performed by adjusting the magnetic field.

TT 25.13 Tue 13:00 H9

Quantum state renormalization group approach to symmetry-protected topological phases — •Ching-Yu Huang[1], Frank Pollmann[1], Feng-Li Lin[2], and Xie Chen[3] — [1]MPIPKS, Dresden,Germany — [2]NTNU, Taipei, Taiwan — [3]UC Berkeley,Berkeley, USA

Topologically phases do not break symmetries and can thus not be characterized by local order parameters. A particular kind of topological phases are the so-called symmetry-protected topological phases (SPTP) which are only distinct from a trivial phase as long as certain symmetries are preserved. The first example of a SPTP is the Haldane phase in S=1 spin chains. We use a symmetry preserving quantum state renormalization group (QSRG) method to characterize SPTP. The QSRG removes short range entanglement and yields a fixed point state which is then used to characterize the phase. For this, we first apply the infinite time-evolving block decimation (iTEBD) method to numerically find the ground state wave function which is then used as initial state for the QSRG procedure. As a simple example we study the one-dimensional Haldane phase. We then extend the method to two dimensions, and study the SU(2) symmetric, two-dimensional quantum spin-3/2 systems on the honeycomb lattice as well as a recently introduced model which realizes a SPTP.