TT 61: Correlated Electrons: 1D Theory

Time: Wednesday 16:30–18:00 Location: H 3010

TT 61.1 Wed 16:30 H 3010

Phase diagram of the extended anyon Hubbard model in one dimension — •Sebastian Eggert[1], Martin Bonkhoff[2], Kevin Jägering[1], Shijie Hu[3], Axel Pelster[1], and Imke Schneider[1] — [1]University of Kaiserslautern-Landau, Landesforschungszentrum OPTIMAS — [2]Universität Hamburg — [3]Beijing Computational Science Research Center

We study one-dimensional lattice anyons with extended Hubbard interactions. At unit filling a repulsive next-nearest neighbor interaction generally leads to gapped phases, but it is far from trivial which correlations are the dominant ones as a function of topological exchange angle and on-site interaction U. We find that a careful derivation of all terms in the Luttinger liquid theory predicts an intermediate phase between a Mott insulator for large repulsive U and a charge density wave at negative U. As a function of exchange angle the intermediate phase changes from Haldane insulator for pseudo bosons to a dimerized phase for pseudo fermions at an interesting multicritical point. Our results are confirmed by extensive numerical simulations.

TT 61.2 Wed 16:45 H 3010

Finite one-dimensional anyons with fixed boundary condition: The Anyonic Luttinger Liquid — •Pascal Jung[1], Martin Bonkhoff[2], Imke Schneider[1], and Sebastian Eggert[1] — [1]University of Kaiserslautern-Landau, Landesforschungszentrum OPTIMAS — [2]Universität Hamburg

Recently lattice anyons in one-dimension have been the center of theoretical and experimental research as a prototypical system with statistically generated interactions. Due to the fundamentally broken parity and the different velocities in the left and right direction, it is non-trivial to find the many-body solution for standing waves in a finite 1D system with box-like boundary conditions. We now describe how the corresponding Luttinger liquid theory with a current-density coupling can be solved by a novel mode expansion which incorporates the correct reflection conditions for fixed boundary condition. It is therefore possible to fully calculate the asymptotic space-time correlation function and determine the corresponding low-energy structure factor, which provides a characteristic hallmark for the Anyonic Luttinger Liquid.

TT 61.3 Wed 17:00 H 3010

Influence of oxygen orbitals on the pairing behavior in the Emery model for doped ladders — •Gökmen Polat and Eric Jeckelmann — Institut für Theoretische Physik, Leibniz Universität Hannover

We investigate the Emery model on ladder-like lattices including two legs of copper d-orbitals and various numbers of oxygen p-orbitals. Various periodic ladder structures are considered with unit cells Cu_nO_m with ratio n/m from 2/5 to 2/3. We calculate gaps, pair binding energy, density distribution, and pairing correlation functions on ladders with open boundary conditions using the density matrix renormalization group (DMRG). We show that the presence or absence of chain-end p-orbitals can lead to the formation of localized boundary states and strongly influences the pairing properties at low doping. More generally, the pairing behavior of finite-size ladders upon hole or electron doping depends sensitively on which p-orbitals are included and on the strength of their hybridization with the copper d-orbitals. We show that these finite-size effects play a role in the apparent failure of the Emery model for cuprate ladders that has been reported recently [1].
[1] Song et al., Phys. Rev. B 107 (2023) L241108

TT 61.4 Wed 17:15 H 3010

Valence-bond order in quantum spin chains with a dissipative spin-Peierls coupling — •Manuel Weber — Institut für Theoretische Physik and Würzburg-Dresden Cluster of Excellence ct.qmat, Technische Universität Dresden, Germany

Quantum spin chains exhibit critical phases of matter that might become unstable when coupled to environmental degrees of freedom. Here, we study the effect of bond dissipation on the one-dimensional antiferromagnetic spin-1/2 Heisenberg model. In analogy to the spin-Peierls problem, the dissipative bath is described by local harmonic oscillators that modulate the spin exchange coupling, but instead of a single boson frequency we consider a continuous bath spectrum $\propto \omega^s$. Using an exact quantum Monte Carlo method for retarded interactions, we show that for $s < 1$ any finite coupling to the bath induces valence-bond-solid order, whereas for $s > 1$ the critical phase of the isolated chain remains stable up to a finite critical coupling. We find that, even in the presence of the gapless bosonic spectrum, the spin-triplet gap remains well defined for any system size, from which we extract a dynamical critical exponent of $z = 1$. We provide evidence for a Berezinskii-Kosterlitz-Thouless quantum phase transition that is governed by the $SU(2)_1$ Wess-Zumino-Witten model. Our results suggest that the critical properties of the dissipative system are the same as for the spin-Peierls model, irrespective of the different interaction range, i.e., power-law vs. exponential decay, of the retarded dimer-dimer interaction, indicating that the spin-Peierls criticality is robust with respect to the bosonic density of states.

TT 61.5 Wed 17:30 H 3010

Quantum simulation of the tricritical Ising model in tunable Josephson junction ladders — •Niklas Tausendpfund[1,2], Lorenzo Maffi[3], Matteo Rizzi[1,2], and Michele Burrello[3] — [1]Peter Grünberg Institut 8, Forschungszentrum Jülich, Jülich, Germany — [2]Institute for Theoretical Physics, University of Cologne, Köln, Germany — [3]Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark

Modern hybrid superconductor-semiconductor Josephson junction arrays are a promising platform for analog quantum simulations. Their controllable and non-sinusoidal energy/phase relationship opens the way to implement non-trivial interactions and to study the emergence of exotic quantum phase transitions. Here we present the analysis of a 2-leg ladder geometry composed of Josephson junctions. Our results support the existence of tricritical Ising phase transitions based on bosonization and matrix product state techniques. This proposal provides a useful one-dimensional building block for designing exotic topological orders in two-dimensional scalable Josephson junction arrays.

TT 61.6 Wed 17:45 H 3010

Stability of Floquet-Bloch states in 1D strongly correlated fermions subject to perturbations — •Karun Gadge and Salvatore R. Manmana — Institute for Theoretical Physics, Georg-August-University Goettingen

Recent experiments have shown many exciting applications of Floquet engineering, where the interaction of the light field with electrons in materials is used to tailor the band structure. However, for strongly correlated systems, many questions concerning the formation and stability of these Floquet-Bloch states (FBs) are still open. Here, we investigate for the influence of electron-electron interactions, a perturbing noise in the coherent driving, and the presence of electron-phonon interactions on the FBs visible in time-resolved single-particle spectral functions. In particular, using exact diagonalizations and matrix product states (MPS) we treat a chain of interacting spinless fermions in 1D, which for strong interactions forms a correlated charge density wave insulator. Even in the presence of strong electron-electron interactions, we find replicas of the full holon continuum in the spectral function, as well as an aditional in-gap mode related to the Villain mode of quantum antiferromagnets at low temperatures [1]. We discuss results for different intensity and frequency of the light field, as well as for the stability of the FBs in the presence of classical phonons and incoherent noise in the driving.
[1] A. Osterkorn, C. Meyer, S.R. Manmana, Commun. Phys. 6 (2023) 245