TT 67: Cold Atomic Gases and Superfluids

Time: Thursday 16:30–18:30 Location: HSZ 204

TT 67.1 Thu 16:30 HSZ 204

Real time dynamics of impurity and disorder scattering with interacting Fermion wave packets — •Sebastian Eggert, Kevin Jägering, Imke Schneider, Benajmin Nagler, and Artur Widera — Physik and OPTIMAS, Technische Universität Kaiserslautern

Recent advances for ultra-cold gases allow the controlled scattering by disorder and localized impurities using moving interacting Fermion wave packets in a trap after a quick displacement in position. We analyze the damping and scattering behavior from large scale numerical t-DMRG simulations in 1D as a function of interaction, displacement and disorder strength in a regime where a comparison with our experiments is possible. Attractive interactions make the wave-packets more susceptible for both single impurities and disorder scattering, which leads to a significant larger damping and quicker breakdown of the oscillations. Repulsive interactions have a much smaller effect, but overall a reduction of scattering can be observed. The corresponding experiments for 3D scattering show maximum stability and minimal damping near the unitary point.

TT 67.2 Thu 16:45 HSZ 204

Damping of the Anderson-Bogolyubov mode in Fermi mixtures by spin and mass imbalance — •Piotr Zdybel — Institute of Theoretical Physics, Faculty of Physics, University of Warsaw, Warsaw, Poland

During the speech, we will present the results of a study about the temporally nonlocal contributions to the gradient expansion of the pair fluctuation propagator for spin- and mass-imbalanced Fermi mixtures. These terms are related to damping processes of sound-like (Anderson-Bogolyubov) collective modes and are relevant for the structure of the complex pole of the pair fluctuation propagator. We derive conditions under which damping occurs even at zero temperature for large enough mismatch of the Fermi surfaces. We compare our analytical results with numerically computed damping rates of the Anderson-Bogolyubov mode.

[1] P. Zdybel and P. Jakubczyk, Phys. Rev. A 100, 053622 (2019)

TT 67.3 Thu 17:00 HSZ 204

Detecting topology in interacting fermionic wires via postquench observables — Andreas Haller[1], Pietro Massignan[2,3], and •Matteo Rizzi[4,5] — [1]Institute of Physics, Johannes Gutenberg University, D-55099 Mainz, Germany — [2]Departament de Fìsica, Universitat Politècnica de Catalunya, Campus Nord B4-B5, 08034 Barcelona, Spain — [3]ICFO – Institut de Ciencies Fotoniques, The Barcelona Institute of Science and Technology, 08860 Castelldefels (Barcelona), Spain — [4]Forschungszentrum Jülich, Institute of Quantum Control, Peter Grünberg Institut (PGI-8), 52425 Jülich, Germany — [5]Institute for Theoretical Physics, University of Cologne, D-50937 Köln, Germany

We exploit a simple observable called "mean chiral displacement" (MCD) for interacting fermionic wires and study numerically the interacting Su-Schrieffer-Heeger (SSH) chain by means of matrix product state calculations. In particular, we propose to study the time-evolution of a simple local quench which relates the MCD to the many-body topological invariant of the Hamiltonian for weakly-correlated interacting models. We study both a short-range correlated and a long-correlated model exhibiting topological/trivial insulators and a (trivial) symmetry breaking phase, and we link the behavior of the MCD to all three phases. We provide an experimental blueprint to obtain the long-range correlated model hosting all three phases.

TT 67.4 Thu 17:15 HSZ 204

Reduced-density-matrix functional theory for the N-boson Hubbard model: Universal functionals, v-representability and quantum depletion as emerging phenomenon — •Jakob Wolff[1], Carlos Benavides-Riveros[1], Christian Schilling[2,3], and Miguel Alexandre Lopes Marques[1] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06120 Halle (Saale), Germany — [2]Department of Physics, Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München, 80333 München, Germany — [3]Wolfson College, University of Oxford, Oxford OX2 6UD, United Kingdom

The Hohenberg-Kohn theorem and its generalization to non-local external potentials initiated the development of density and one-matrix functional theory. While such methods were applied so far only to fermionic quantum systems, the realization of ultracold gases urges the development of analogous bosonic functionals. In the form of the Hubbard dimer model for arbitrary number of bosons, we study the building block of one-dimensional optical lattices. Close to the Bose-Einstein condensation (BEC), we determine the one-matrix functional analytically. Remarkably, its gradient is found and proven to diverge repulsively in the regime of almost complete BEC. This possibly provides in particular a more fundamental explanation than the concept of quantum depletion for the absence of BEC of full degree in nature. Moreover, we obtain an analytic description of the set of v-representable one-body matrices for all N.

TT 67.5 Thu 17:30 HSZ 204

Finite-temperature effects and quench dynamics in interacting bosonic flux-ladders — •Maximilian Buser[1], Fabian Heidrich-Meisner[2], and Ulrich Schollwöck[1] — [1]Department of Physics, Arnold Sommerfeld Center for Theoretical Physics (ASC), Munich Center for Quantum Science and Technology (MCQST), Fakultät für Physik, Ludwig-Maximilians-Universität München, 80333 München, Germany — [2]Institute for Theoretical Physics, Georg-August-Universität Göttingen, 37077 Göttingen, Germany

Flux-ladders constitute the minimal setup enabling a systematic understanding of the rich physics of interacting particles in strong magnetic fields and in lattices. These systems were also realized in a series of experiments and therefore, they have attracted great interest. We study ground-state phases, quench dynamics, and the effect of finite temperatures in interacting bosonic flux-ladders using matrix-product-state techniques. The focus is on experimentally accessible observables such as the chiral current and the leg-population imbalance; typical particle-current patterns and momentum-distribution functions are exemplified. We demonstrate that quantum quenches from suitably chosen initial states can be used to probe the equilibrium properties in the transient dynamics.

TT 67.6 Thu 17:45 HSZ 204

Topological Thouless pumps in commensurate and incommensurate optical lattices — •Pasquale Marra[1,2] and Muneto Nitta[2] — [1]Graduate School of Mathematical Sciences, The University of Tokyo — [2]Department of Physics, Keio University

Topological quantum pumps can be experimentally realized in cold atoms in optical lattices, by the superposition of two lattices with different, but commensurate spatial periods. These systems exhibit a topologically non-trivial phase where the topological invariant coincides with the quantized charge pumped at each pumping cycle. This quantization is analogous to the quantum Hall effect. Moreover, the charge transferred at well-defined fractions of the pumping period can be quantized as integer fractions of the Chern number. This fractional quantization is topological in nature and it is a direct consequence of the symmetries of the system, and does not rely on the presence of interactions. Here, we describe how to extend these findings to the case of quasiperiodic quantum pumps, which can be obtained by the superposition of two different lattices with incommensurate spatial periods. These quasiperiodic systems have no translational symmetry: It is therefore not possible to define the topological invariant as an integral of the Berry curvature in the momentum space. We will discuss here how to extend the definition of Chern number to the quasiperiodic case, and describe the transport signatures of the corresponding nontrivial topological phases.

TT 67.7 Thu 18:00 HSZ 204

Numerical generation of snapshots for fermionic quantum gas microscopy — •Stephan Humeniuk[1] and Yuan Wan[1,2] — [1]Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China — [2]University of Chinese Academy of Sciences, Beijing 100049, China

Fermionic quantum gas microscope experiments with single-site single-atom resolution have enabled the detection of snapshots of the many-body wavefunction in occupation number space, which has opened the way for analysis techniques that go beyong standard correlation functions. Employing a nested, direct sampling approach for fermion pseudo density matrices as they arise naturally in determinantal quantum Monte Carlo simulations, a stream of Fock space configurations on large systems can be generated numerically. This approach is useful for carefully benchmarking and emulating equilibrium quantum gas microscope experiments.

TT 67.8 Thu 18:15 HSZ 204

Surface chiral excitations in time-reversal broken crystals — •Claudio Benzoni — TUM, Munich, Germany

We have studied an elastic model analogous to the isotropic body but in which the dynamics is non-Newtonian. In the long-wavelength regime this gapless model exhibits non-linear dispersing Rayleigh excitations that propagate in a chiral fashion. We found out that the chirality of the surface waves is determined by an interplay between the elasticity and the term that violates time-reversal symmetry and not only by the sign of the latter. Three regimes have been identified. Realizations of this model can be in two-dimensional Wigner crystals and in gyroscopic metamaterials.