MON 15: Many-Body Quantum Dynamics II

Time: Monday 16:30–18:15 Location: ZHG003

MON 15.1 Mon 16:30 ZHG003

Towards a Many-Body Generalization of the Wigner-Smith Time Delay — •Georg Maier[1], Carolyn Echter[2], Juan Diego Urbina[1], Caio Lewenkopf[3], and Klaus Richter[1] — [1]Institut für Theoretische Physik Universität Regensburg, Regensburg, Germany — [2]Fakultät für Mathematik, Universität Regensburg, 93040 Regensburg, Deutschland — [3]Instituto de Física, Universidade Federal do Rio de Janeiro, 21941-972 Rio de Janeiro, RJ, Brazil

Many body systems with a large number of degrees of freedom are usually described by statistical physics on the theoretical side while experiments usually relay on scattering (e.g. particle physics). Is it possible to relate scattering and statistical physics, or to measure scattering-related observables which directly relate to quantities of statistical physics? At least for single particle systems a close relation exists between the well known Wigner-Smith delay time in scattering theory and the density of states of the scattering system.

I will present a novel ansatz relating a many-body version of dwell-/Wigner-Smith delay time and many body density of states based on the famous Birman-Krein-Friedel-Loyd formula connecting scattering theory and statistical observables in the many-body context. Due to the flexibility of this ansatz it can be used to investigate a wide variety of MB systems. I will discuss interesting scaling behaviors for different systems, like the harmonic trap[1] or the free particle together with the different behavior of bosons, fermions and indistinguishable particles.

[1] C. Echter et. al 2409.08696

MON 15.2 Mon 16:45 ZHG003

Equilibrium, Relaxation and Fluctuations in homogeneous Bose-Einstein Condensates: Linearized Classical Field Analysis — •Nils A. Krause[1,2] and Ashton S. Bradley[1,2] — [1]Department of Physics, University of Otago, Dunedin, New Zealand — [2]Dodd-Walls Centre for Photonic and Quantum Technologies

We present a thorough analysis of the linearized stochastic projected Gross-Pitaevskii equation (SPGPE) describing finite temperature in Bose-Einstein condensates (BECs). Our study reveals an optimal choice for the cut-off that divides the Bose gas into a low energy coherent region forming a classical wave and a high energy thermal cloud acting as a reservoir. Moreover, it highlights the relevance of energy damping, the number conserving scattering between thermal and coherent atoms. We analyze the equilibrium properties and near equilibrium relaxation of a homogeneous BEC in one, two and three dimensions at high phase space density. Simulations of the full nonlinear SPGPE are in close agreement, and extend our arguments beyond the linear regime. Our work suggests the need for a re-examination of decay processes in BECs studied under the neglect of energy damping.

MON 15.3 Mon 17:00 ZHG003

Creating NOON Wavepackets via Resonance and Chaos-Assisted Tunneling of Ultracold Atoms in a Ring — •Diego Morachis and Peter Schlagheck — CESAM Research Unit, University of Liège, 4000 Liège, Belgium

A way to generate microscopic quantum superpositions for repulsively interacting ultracold atoms confined in a ring-shaped trap is proposed. Periodically driving the system renders a mixed phase space where chaotic dynamics coexist with stable resonant islands. These islands act as effective double-well potentials, enabling the confinement of atoms in distinct wavepackets with the possibility of achieving states in a perferctly balanced superposition known as a NOON state. We explore the creation of such states by studying the evolution of experimentally feasible coherent states as initial wavepackets. Parameter sets enabling the self-trapping regime are identified, which suppresses individual tunneling and promotes collective tunneling as the dominant mechanism. By performing exact numerical simulations of the many-body dynamics, we characterize NOON state formation timescales for distinct particle numbers. Preliminary results suggest specific driving windows where this resonance and chaos-assisted approach may generate nonclassical states in atomic traps.

MON 15.4 Mon 17:15 ZHG003

NOON entanglement via quantum control in Bose-Hubbard systems — •Simon Dengis[1], Sandro Wimberger[2,3], and Peter Schlagheck[1] — [1]CESAM Research Unit, University of Liege, 4000 Liege, Belgium — [2]Istituto Nazionale di Fisica Nucleare (INFN), Sezione Milano Bicocca, Gruppo collegato di Parma, Italy — [3]Dipartimento di Matematica, Fisica e Informatica, Università di Parma, Parco Area delle Scienze 7/A, 43124 Parma, Italy

A quantum control protocol is proposed for the creation of NOON states with N ultracold bosonic atoms on two modes, corresponding to the coherent superposition $|N,0\rangle + |0,N\rangle$. This state can be prepared by using a third mode where all bosons are initially placed and which is symmetrically coupled to the two other modes. Tuning the energy of this third mode across the energy level of the other modes allows the adiabatic creation of the NOON state. While this process normally takes too much time to be of practical usefulness, due to the smallness of the involved spectral gap, it can be drastically boosted through counterdiabatic driving which allows for efficient gap engineering. We then extend this entanglement protocol to the realization of multi-mode NOON states by employing a generic star-shaped Bose-Hubbard model with an arbitrary number of modes. We demonstrate that this process can be implemented in terms of static parameter adaptations that are experimentally feasible with ultracold quantum gases using Geodesic Counterdiabatic Driving, which saturates the quantum speed limit.

MON 15.5 Mon 17:30 ZHG003

Stability of Floquet sidebands and quantum coherence in 1D strongly interacting spinless fermions — •Karun Gadge and Salvatore R Manmana — Institute for Theoretical Physics, Georg-August-University Goettingen, Germany

For strongly correlated quantum systems, fundamental questions about the formation and stability of Floquet-Bloch sidebands (FBs) upon periodic driving remain unresolved. Here, we investigate the impact of electron-electron interactions and perturbations in the coherence of the driving on the lifetime of FBs by directly computing time-dependent single-particle spectral functions using exact diagonalization (ED) and matrix product states (MPS). We study interacting metallic and correlated insulating phases in a chain of correlated spinless fermions. At high-frequency driving we obtain clearly separated, long-lived FBs of the full many-body excitation continuum. However, if there is significant overlap of the features, which is more probable in the low-frequency regime, the interactions lead to strong heating, which results in a significant loss of quantum coherence and of the FBs. Similar suppression of FBs is obtained in the presence of noise. The emerging picture is further elucidated by the behavior of real-space single-particle propagators, of the energy gain, and of the momentum distribution function, which is related to a quantum Fisher information that is directly accessible by spectroscopic measurements.

Ref: arXiv:2502.12643

MON 15.6 Mon 17:45 ZHG003

Transport in quantum wires: Fractional charges and non-linear Luttinger liquids — •Sebastian Eggert[1], Flávia B. Ramos[1], Imke Schneider[1], and Rodrigo G. Pereira[2] — [1]University of Kaiserslautern-Landau — [2]Universidade Federal do Rio Grande do Norte, Natal

This talk will address the question about how a right-moving unit charge propagates along an interacting spinless wire. Using adaptive time-dependent DMRG, we observe that the charge spontaneously separates into three distinct parts: a fractional charge with free particle dynamics and left- and right-moving parts. As we will show the results are in full agreement with the non-linear Luttinger theory and provide deep insights into the universal correlated nature of these emergent particles. Corresponding out-of-equilibrium transport measurements offer a direct method to extract the interaction parameters governing correlations in the system even at higher energies.

MON 15.7 Mon 18:00 ZHG003

Many-body interference of anyons on a one-dimensional lattice — •Peter Robert Förderer[1], Gabriel Dufour[1], and Andreas Buchleitner[1,2] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg, Germany — [2]EUCOR Centre for Quantum Science and Quantum Computing, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg, Germany

In addition to bosons and fermions, one- or two-dimensional systems can host anyons with non-trivial exchange phase φ. Here, we theoretically explore the dynamics of anyons on a one-dimensional lattice. This anyon-Hubbard model can be mapped onto a generalized Bose-Hubbard model with an occupation-dependent tunneling phase. In particular, we study the Hong-Ou-Mandel interference of two anyons scattering on a potential barrier. We show that the anyonic phase not only enables to interpolate between bosonic bunching and fermionic antibunching but also introduces new effects such as the formation of bound states and preferential scattering in one direction.