TT 45: Correlated Electrons: Nonequilibrium Quantum Many-Body Systems 3 (jointly with DY)

Time: Tuesday 14:00–16:00 Location: H 3010

TT 45.1 Tue 14:00 H 3010

Real-time decay of a highly excited charge carrier in the one-dimensional Holstein model — •Florian Dorfner[1], Lev Vidmar[1], Christoph Brockt[2], Eric Jeckelmann[2], and Fabian Heidrich-Meisner[1] — [1]Ludwig-Maximilians-Universität München, Germany — [2]Leibniz Universität Hannover, Germany

We study the real-time dynamics of a highly excited charge carrier coupled to quantum phonons via a Holstein-type electron-phonon coupling [1]. This is a prototypical example for the non-equilibrium dynamics in an interacting many-body system where excess energy is transferred from electronic to phononic degrees of freedom. We use an efficient numerical method, i.e., diagonalization in a limited functional space, to study the non-equilibrium dynamics on a finite one-dimensional chain. We perform a comprehensive analysis of the time evolution in different parameter regimes by calculating the electron, phonon and electron-phonon coupling energies, and the electronic momentum distribution function. For example, we demonstrate that in the weak coupling regime, the relaxation dynamics obtained from the Boltzmann equation agrees very well with the numerical data. We also study the time dependence of the eigenstates of the single-site reduced density matrix, the so-called optimal phonon modes, unveiling that their structure in non-equilibrium contains very useful information for the interpretation of the numerical data. Support from the DFG through FOR 1807 is gratefully acknowledged.

[1] Dorfner et al, arXiv:1411.5074 (2014).

TT 45.2 Tue 14:15 H 3010

Measure of equilibration in Luttinger liquids — •Mariya Medvedyeva and Stefan Kehrein — Goettingen University, Goettingen, Germany

We consider the properties of the Luttinger liquid in the echo protocol (forward evolution in time followed by the backward evolution of slightly perturbed system) and explore the relation of the Loschmidt echo (the overlap of the initial and final wavefunctions) and the measurable properties of the system. We first study the linear Luttinger liquid as an example of an integrable system and find that the momentum distribution function exhibits almost complete recurrence while the Loschmidt echo does not, as the diagonal basis is different during the forward and backward time evolution. For a nonlinear Luttinger liquid the recurrence strength of the momentum distribution function drops as the nonlinearity of the fermion dispersion relation grows. We conclude that there is no simple relation of the Loschmidt echo to the behavior of the observables and that more work is needed to understand how to interpret the echo in the context of experiment.

TT 45.3 Tue 14:30 H 3010

Quantum Freezing Effect in 1D SU(N) Hubbard Systems — •Salvatore R. Manmana, Mariya V. Medvedyeva, and Johannes M. Oberreuter — Institut f. Theoretische Physik, Georg-August-Universität Göttingen, D-37077 Göttingen

We investigate the time evolution of SU(N) Fermi-Hubbard systems by releasing initially trapped particles onto an empty lattice. Using the time-dependent DMRG and perturbative approaches, we find that in one spatial dimension for large enough filling and values of N, repulsive interactions cause the dynamics to develop a very strong freezing effect, i.e., on the time scales accessible, particle motion is essentially suppressed. We relate this finding to the quantum distillation effect previously reported for SU(2) Fermi-Hubbard systems and discuss its relevance for ongoing experiments with alkaline earth atom experiments on optical lattices.

TT 45.4 Tue 14:45 H 3010

Thermalization Dynamics in the Interacting Luttinger Model after a Quantum Quench — •Michael Buchhold and Sebastian Diehl — Institut für Theoretische Physik, TU Dresden, 01062 Dresden

Interacting Luttinger Liquids form a paradigmatic example of one-dimensional interacting fermions with a weak integrability breaking non-linearity. The thermalization dynamics of this model after an interaction quench is studied in a Keldysh non-equilibrium framework by means of Dyson-Schwinger equations.

After the quench, the ballistic dephasing of the phononic modes leads to correlations corresponding to a prethermal state, well described by a generalized Gibbs ensemble (GGE). This behavior is however overwritten on short distances by a sub-ballistically spreading thermal regime. While the GGE still features algebraic correlations in space and time with a corresponding non-equilibrium exponent, the thermal state shows the well-known exponential decay of correlations.

TT 45.5 Tue 15:00 H 3010

Spectral Properties of One-Dimensional Fermi Systems after an Interaction Quench — •Christian Klöckner, Dante Marvin Kennes, and Volker Meden — Institut für Theorie der Statistischen Physik, RWTH Aachen University and JARA - Fundamentals of Future Information Technology, 52056 Aachen, Germany

We show that the single-particle spectral properties of gapless one-dimensional Fermi systems in the Luttinger liquid state reached at intermediate times after an abrupt quench of the two-particle interaction are highly indicative of the unusual nonequilibrium nature of this state. Analytical and numerical insights gained by applying bosonization are presented. The resulting line shapes of the momentum-integrated and -resolved spectral functions strongly differing from their ground state as well as finite temperature equilibrium counterparts.

TT 45.6 Tue 15:15 H 3010

Inhomogeneous Quantum Quenches in the 1D Hubbard Model — •Ernst von Oelsen[1], Götz Seibold[1], and Jörg Bünemann[2] — [1]BTU Cottbus-Senftenberg — [2]Philipps-Universität Marburg

We investigate the dynamics of a many-electron system after a sudden quench of the single-particle potential and of the interaction strength. The calculation is based on the single-band Hubbard model and the time-dependent Gutzwiller theory. Our study is focussed on finite-size systems with lattice-site dependent on-site potentials and interaction strengths.

We compute the time-evolution of the electrons' density matrix and of the electrons double occupancy by fully integrating the equations of motion. Thus, our approach is not limited to small amplitudes but allows for a detailed study of the dependence of the electrons' excitation energies on both the interaction strength and the strength of the quench. Our results are compared to those from exact diagonalization techniques, from the small-amplitude limit and from a Hartree–Fock calculation.

TT 45.7 Tue 15:30 H 3010

Thermalization rates in a 1d Fermi-Hubbard model with slightly broken integrability for various fillings — •Fabian Biebl and Stefan Kehrein — Institut für Theoretische Physik, Georg-August-Universität Göttingen, D-37077 Göttingen, Germany

Understanding relaxation in quantum systems is essential to determine whether an experimental setup can be described by equilibrium concepts. For example integrable systems do not thermalize, but develop into non-thermal steady states. By slightly breaking integrability, thermalization of such non-thermal (prethermalized) states becomes possible. An important question is to identify the corresponding timescale for thermalization due to the breaking of integrability.

We investigate this question for a fermionic Hubbard chain in the thermodynamic limit. The integrability breaking term is a small next to nearest neighbor hopping term [1,2]. The thermalization timescale is extracted from the quantum Boltzmann equation and depends strongly on temperature, especially when one goes away from half filling. The dependence on filling is connected to Umklapp-processes and we study this dependence systematically.

[1] M. L. R. Fuerst et al., Phys. Rev. E 86, 031122 (2012).
[2] M. L. R. Fuerst et al., Phys. Rev. E 88, 012108 (2013).

TT 45.8 Tue 15:45 H 3010

Time evolution of the ohmic spin boson model at finite bias in the weak coupling limit — •Carsten Lindner and Herbert Schoeller — Institut für Theorie der Statistischen Physik, RWTH Aachen

The spin boson model is a prominent model which describes dissipation in a quantum mechanical two-state system caused by an energy exchange with the environment. Proposed for applications in various fields of condensed matter physics, it has been discussed widely for more than twenty years. However, a full systematic analysis of the weak coupling regime has not been done for a long time. Recently, the time evolution of the ohmic spin boson model at zero bias has been investigated in the case of weak coupling where the interaction with the environment can be regarded as a small perturbation [1]. Therefore, a non-equilibrium renormalization group (RG) method, which has come to be known as the real-time RG (RTRG), has been employed to determine its time evolution. The choosen approach allows to obtain the time evolution in a controlled way which means that the renormalized coupling parameters stay small for arbitrarily long times. Beside predicting the dominant exponential time evolution, this method also enables us to address the time scaling behavior of the pre-exponential functions precisely. Based on this insight, we have investigated the ohmic spin boson model at finite bias accordingly, leading to new results on all time scales.

[1] O. Kashuba and H. Schoeller, Phys. Rev. B 87, 201402(R) (2013)