TT 62: Nonequilibrium Quantum Many-Body Systems II (joint session TT/DY)

Time: Wednesday 15:00–18:30 Location: H 3010

Invited Talk TT 62.1 Wed 15:00 H 3010

Efficient Simulation of Quantum Thermalization and Dynamics — •Frank Pollmann — Department of Physics, Technical University of Munich, 85748 Garching, Germany

The past decade has seen a great interest in the question about whether and how quantum many-body system locally thermalize. It has been driven by theoretical findings involving the long sought demonstration that many-body localization (MBL) exists as well as the derivation of exact bounds on chaos. In my talk, I will introduce matrix-product state (MPS) based methods that allow for an efficient numerical simulation of the quantum thermalization dynamics. Firstly, I will show that, contrary to the common belief that the rapid growth of entanglement restricts simulations to short times, the long time limit of local observables can be well captured using the MPS based time-dependent variational principle. Secondly, I will discuss how mixed states can be represented using dynamically disentangled purified states. These novel methods allow to extract transport coefficients, e.g. the energy diffusion constant, efficiently.

TT 62.2 Wed 15:30 H 3010

Prethermalization without canonical transformations — Marc Alexander and •Marcus Kollar — Theoretische Physik III, Universität Augsburg

Weakly quenched quantum systems often exhibit a prethermalization regime on short to intermediate time scales, which is usually derived using canonical transformations [1,2]. We show how to skip this step and directly obtain the transient behavior, the long-time average, and the dressed constants of motion for arbitrary time-dependent protocols. We apply these results to fermionic Hubbard models for a variety of time-dependent perturbations.

[1] M. Moeckel and S. Kehrein, Phys. Rev. Lett. **100**, 175702 (2008)
[2] M. Kollar et al., Phys. Rev. B **84**, 054304 (2011)

TT 62.3 Wed 15:45 H 3010

Universal prethermal states in slowly driven many-body systems — •Tobias Gulden[1], Netanel Lindner[1], Erez Berg[2], and Mark Rudner[3] — [1]Technion - Israel Institute of Technology — [2]University of Chicago — [3]University of Copenhagen

A key challenge in the search for new non-equilibrium phases of matter is the tendency of closed many-body systems to indefinitely absorb energy from a driving field. Generically this leads to an infinite temperature state where any interesting quantum, and in particular topological, effects are washed out. Here we show that in fact heating can be used as a resource for establishing universal prethermal behavior which exhibits topological phenomena. The prethermalization regime which we consider occurs for low driving frequencies, and persists throughout a long time window. Recently such prethermal states were found in one dimensional topological pumps [Lindner, Berg, Rudner, PRX 2017]. We provide bounds on the lifetimes of states, study different manifestations of universal prethermal behavior in a variety of systems, and discuss probes for observing topological properties.

TT 62.4 Wed 16:00 H 3010

Non-Equilibrium Steady State Quantum Systems — •Michael Schuett and Markus Mueller — Condensed Matter Theory Group, Paul Scherrer Institute, CH-5232 Villigen PSI, Switzerland

Recent experimental advances have sparked a growing interest in quantum systems out of equilibrium. Such systems can exhibit phenomena not found in equilibrium. A frequent price payed for this freedom is the intractability of the non-equilibrium system. Here we consider a tractable toy model, rich enough to exhibit interesting non-equilibrium properties in a driven steady state. Being a well characterized fixed point, the steady state selects a specific state from the vast set of out of equilibrium states. The scenario we consider are non-interacting Fermions driven around a mesoscopic scatterer. We construct the driven, current-carrying many-body state, based on non-interacting scattering states and determine the non-equilibrium Friedel oscillations. We show, based on non-interacting scattering states that experimentally detectable oscillatory magnetic field patterns arise from the emerging current pattern. Finally we generalize our construction of the steady states to include interactions and conclude with an outlook on interaction induced instabilities or chaoticity.

TT 62.5 Wed 16:15 H 3010

Non-equilibrium steady state of the ionic Hubbard model in strong electric fields — •Yusuf Mohammed[1] and Martin Eckstein[2] — [1]Universität Hambrug, Hamburg, Germany — [2]FAU, Erlangen, Germany

We investigate the transport properties and non-equilibrium steady state phases of the dissipative ionic Hubbard model driven by an electric field. In the ionic Hubbard model, metallic behavior is enhanced by a competition of band insulating and Mott insulating behavior. The system is analyzed by means of the inhomogeneous dynamical mean-field theory (DMFT), using the iterated perturbation theory as impurity solver. The steady states of this model are accessed directly through the Keldysh contour formalism. We found that with increasing electric field the sublattice polarization reduces, leading to a decrease in the screening of the gap and an increase in the electronic scattering rate. This results in a smaller current in the nonlinear regime of correlated ionic insulators compared the non interacting case. In addition, we observed a quasi-thermal distributions even in the negative differential resistance regime, due to electron-electron scattering.

15 min. break.

TT 62.6 Wed 16:45 H 3010

Irreversible dynamics in quantum many-body systems — •Markus Schmitt[1,2] and Stefan Kehrein[1] — [1]Institute for Theoretical Physics, Georg-August-Universität Göttingen, Germany — [2]Max-Planck-Institute for the Physics of Complex Systems, Dresden, Germany

Irreversibility, despite being a necessary condition for thermalization, still lacks a sound understanding in the context of quantum many-body systems. In our work [1] we approach this question by studying the behavior of generic many-body systems under imperfect effective time reversal, where the imperfection is introduced as a perturbation of the many-body state at the point of time reversal. Based on numerical simulations of the full quantum dynamics we demonstrate that observable echos occurring in this setting decay exponentially with a rate that is intrinsic to the system meaning that the dynamics is effectively irreversible.

[1] M. Schmitt and S. Kehrein, arXiv:1711.00015

TT 62.7 Wed 17:00 H 3010

Absence of dynamical localization in interacting driven systems — •David J. Luitz[1], Yevgeny Bar Lev[2,3], and Achilleas Lazarides[3] — [1]Physik Department T42, Technische Universität München, Germany — [2]Department of Condensed Matter Physics, Weizmann Institute of Science, Rehovot, Israel — [3]Max-Planck-Institut für Physik komplexer Systeme, Dresden, Germany

Using a numerically exact method we study the stability of dynamical localization to the addition of interactions in a periodically driven isolated quantum system which conserves only the total number of particles. We find that while even infinitesimally small interactions destroy dynamical localization, for weak interactions density transport is significantly suppressed and is asymptotically diffusive, with a diffusion coefficient proportional to the interaction strength. For systems tuned away from the dynamical localization point, even slightly, transport is dramatically enhanced and within the largest accessible systems sizes a diffusive regime is only pronounced for sufficiently small detunings.

[1] D. J. Luitz, Y. Bar Lev, A. Lazarides, *SciPost Phys.* **3**, 029 (2017)

TT 62.8 Wed 17:15 H 3010

Impurity induced quench dynamics in shallow Fermi seas: an analytic treatment — •Conor Jackson and Bernd Braunecker — University of St Andrews, St Andrews, United Kingdom

We investigate the Loschmidt echo for a system of free fermions after the introduction of a local quench impurity, taking account of the finite band depth. For a system with a large bandwidth, the sudden introduction of an impurity leads to the well-known Fermi-Edge Singularity and a characteristic power law decay in the Loschmidt echo in the long time limit. We examine analytically the effect of the finite band bottom at intermediate time scales, using a Riemann-Hilbert approach to evaluate the functional determinants induced by the fermionic statistics. On these time scales we find disruption of the entire Fermi sea, rather than simply the surface shakeup which leads to the standard result, and we can provide an analytic explanation of previous numerical results.

TT 62.9 Wed 17:30 H 3010

Anomalous Spin Precession under a Geometrical Torque — •Christopher Stahl[1,2] and Michael Potthoff[1] — [1]I. Institut für Theoretische Physik, Universität Hamburg — [2]Institut für Theoretische Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg

Precession and relaxation predominantly characterize the real-time dynamics of a spin driven by a magnetic field and coupled to a large Fermi sea of conduction electrons. We demonstrate an anomalous precession with frequency higher than the Larmor frequency or with inverted orientation in the limit where the electronic motion adiabatically follows the spin dynamics. For a classical spin, an analytic expression which identifies the finite spin Berry curvature of the conduction electrons as the origin of the anomalous frequency is derived. Complementary studies for the minimal model of two coupled spins and calculations for the Kondo-impurity model verify that the anomalous precession is also present for a quantum spin and suggest that the derived formula for the frequency of the classical spin can be applied to the quantum case by replacing the classical spin components by the corresponding expectation values.

[1] C. Stahl and M. Potthoff, PRL 119, 227203 (2017)

TT 62.10 Wed 17:45 H 3010

The Lipkin-Meshkov-Glick model with Markovian dissipation — •João S. Ferreira and Pedro Ribeiro — CeFEMA, Instituto Superior Técnico, Universidade de Lisboa Av. Rovisco Pais, 1049-001 Lisboa, Portugal

Motivated by recent prototypes of engineered atomic spin devices, we study a fully connected system of n spins $1/2$, modeled by the Lipkin-Meshkov-Glick (LMG) model of a collective spin $s = n/2$, in the presence of Markovian dissipation processes. Employing semi-classical and variational methods and a systematic Holdstein-Primakov mapping, we determine the semi-classic equations of motion, the phase diagram and spectral properties of the Liouvillian by studying both the thermodynamic limit and $1/s$ corrections. Our approach reveals the existence of: dynamical phase transitions for finite s, tri-stable steady state regions and recurrent regions where the system fails to thermalize.

TT 62.11 Wed 18:00 H 3010

Tripartite information and scrambling in quantum lattice models — •Oskar Schnaack[1], Sebastian Paeckel[1], Thomas Köhler[1], Salvatore R. Manmana[1], Stefan Kehrein[1], and Markus Schmitt[1,2] — [1]Institute for Theoretical Physics, Georg-August-Universität Göttingen, Germany — [2]Max-Planck-Institut für Physik komplexer Systeme, Dresden, Germany

The tripartite information has been introduced as a quantitative observable-independent measure of scrambling by Hosur et al. [1]. We investigate its time-evolution for quantum lattice models with tunable integrability breaking and demonstrate that in contrast to integrable models generic systems scramble information irrespective of the chosen partitioning of the lattice. To compute the information measures of interest we introduce exact representations of permutation operators to obtain entanglement entropies of embedded subsystems using matrix product states.

[1] P. Hosur, X.-L. Qi, D. A. Roberts, B. Yoshida, JHEP02 (2016) 004

TT 62.12 Wed 18:15 H 3010

Real-time dual bosons: role of magnetic time scales. — •Sergey Brener — Universität Hamburg, Germany

We describe magnetic dynamics within the framework of dual bosons on keldysh contour. In particular the role of separating of electron and magnetic time-scales is considered.