TT 73: Correlated Electrons: Nonequilibrium Quantum Many-Body Systems 2

Time: Thursday 15:00–18:00 Location: HSZ 304

TT 73.1 Thu 15:00 HSZ 304

Study of dynamical localization in interacting Floquet systems — •Tibor Rakovszky[1], Frank Pollmann[1], Curt von Keyserlingk[2], and Shivaji Sondhi[3] — [1]Physik-Department, Technische Universität München, D-85748 Garching, Germany — [2]Princeton Center for Theoretical Science, Princeton University, Princeton, New Jersey 08544, USA — [3]Department of Physics, Princeton University, Princeton, New Jersey 08544, USA

Since the seminal work of Fishman, Grempel and Prange on the kicked rotator[1], it is known that periodically driven - otherwise known as Floquet - systems can exhibit 'dynamical localization': a variant of Anderson localization in which the particle is localized not in real, but in momentum space. In the past decade it became clear that Anderson localization in real space is robust against sufficiently weak interactions, leading to a phenomenon called many-body localization. It is therefore a natural question to ask whether the dynamical localization, exhibited by periodically driven free particles, also has an interacting analogue. In this talk we review recent results regarding this question and compare them to our own results acquired through large-scale numerical simulations.

[1] S. Fishman, D.R. Grempel and R.E. Prange, Phys. Rev. Lett. 49, 509 (1982)

TT 73.2 Thu 15:15 HSZ 304

Spatiotemporal buildup of density-density correlations in the 2d Hubbard model — •Manuel Kreye and Stefan Kehrein — Institut für Theoretische Physik, Georg-August-Universität Göttingen, Germany

Driven by recent experimental advances in ultracold atomic gases, the dynamical behavior of quantum many-body systems far from equilibrium has gained a lot of interest. The theoretical comprehension of the observations and the prediction of new phenomena require powerful and reliable methods for studying the real-time dynamics of these many-body systems.

In this work, we apply the method of unitary perturbation theory to study the spatiotemporal buildup of density-density correlations in the two-dimensional Hubbard model after a weak interaction quench. We present analytical results for both susceptibilities and correlation functions on all time scales.

TT 73.3 Thu 15:30 HSZ 304

Spatiotemporal correlation build-up after an interaction quench in the Luttinger model — •Nils O. Abeling, Markus Schmitt, Manuel Kreye, and Stefan Kehrein — Institut für Theoretische Physik, Georg-August-Universität, Göttingen

We study the evolution of density-density correlations at different times and distances in the exactly solvable Luttinger model after a sudden quench from the ground state. We discuss the difference between correlations and susceptibilities, and how these results can be interpreted from the point of view of Lieb-Robinson bounds. For the correlation functions we specifically show that pre-quench entanglement in the ground state leads to algebraically decaying long distance tails outside the light cone.

TT 73.4 Thu 15:45 HSZ 304

Transport dynamics in a quenched tunnel-coupled Luttinger liquid — •Filippo M. Gambetta[1], Fabio Cavaliere[1], Maura Sassetti[1], Alessio Calzona[1,2], Roberta Citro[3], and Matteo Carrega[4] — [1]Università di Genova and SPIN-CNR, Genova, Italy — [2]University of Luxembourg, Luxembourg — [3]Università di Salerno and SPIN-CNR, Fisciano (SA), Italy — [4]NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Pisa, Italy

The transport dynamics of a quenched Luttinger liquid tunnel-coupled to a fermionic non-interacting probe is investigated. In the transient dynamics, we show that for a sudden quench of the electron interaction universal power-law decay in time of the tunneling current occurs, ascribed to the presence of entangled compound excitations created by the quench. In sharp contrast to the usual nonuniversal power-law behavior of a zero-temperature nonquenched Luttinger liquid, the steady-state tunneling current is Ohmic and can be explained in terms of an effective quench-activated heating of the system. Furthermore, by studying the fractionalization of charge and energy injected through the tunneling junction, we demonstrate that in the steady state the charge fractionalization ratio is unaffected by the pre-quenched parameters. On the contrary, due to the post-quench non-equilibrium spectral function, the energy partitioning ratio is strongly modified, reaching values even larger than one. This is a peculiar feature of the non-equilibrium dynamics of the quench process and it is in sharp contrast with the non-quenched case, where the ratio is bounded by one.

TT 73.5 Thu 16:00 HSZ 304

Out-of-equilibrium density dynamics of a quenched fermionic system — •Sergio Porta[1], Filippo M. Gambetta[1,2], Fabio Cavaliere[1,2], Niccolò Traverso Ziani[3], and Maura Sassetti[1,2] — [1]Università di Genova, Genova, Italy — [2]SPIN-CNR, Genova, Italy — [3]University of Würzburg, Würzburg, Germany

Using a Luttinger liquid theory we investigate the time evolution of the particle density of a one-dimensional fermionic system with open boundaries and subject to a finite duration quench of the inter-particle interaction. We provide analytical and asymptotic solutions to the unitary time evolution of the system, showing that both switching on and switching off the quench ramp create light-cone perturbations in the density. The post-quench dynamics is strongly affected by the interference between these two perturbations. In particular, we find that the discrepancy between the time-dependent density and the one obtained by a generalized Gibbs ensemble picture vanishes with an oscillatory behavior as a function of the quench duration, with local minima corresponding to a perfect overlap of the two light-cone perturbations. For adiabatic quenches, we also obtain a similar behavior in the approach of the generalized Gibbs ensemble density towards the one associated with the ground state of the final Hamiltonian.

TT 73.6 Thu 16:15 HSZ 304

Multiple particle-hole pair creation in the Fermi-Hubbard model — Nicolai ten Brinke, Manuel Ligges, Uwe Bovensiepen, Ralf Schützhold, and •Friedemann Queisser — Fakultät für Physik, Universität Duisburg-Essen, Lotharstraße, Duisburg 47048, Germany

We study the Fermi-Hubbard model in the strongly correlated Mott phase under the influence of a harmonically oscillating hopping rate $J(t) = J_0 + \triangle J \cos(\omega t)$ [1]. Apart from the well-known fundamental resonance where the frequency ω of this oscillation equals (or a little exceeds) the Mott gap, we also find higher-order resonances where multiple particle-hole pairs are created when ω is near an integer multiple of the gap. These findings should be relevant for experimental realizations such as ultra-cold fermionic atoms in optical lattices or pump-probe experiments using laser pulses incident on correlated electrons in solid state materials.

[1] N. ten Brinke, M. Ligges, U. Bovensiepen and R. Schützhold, arXiv:1602.00871

15 min. break.

TT 73.7 Thu 16:45 HSZ 304

The nature of the pressure-induced metallization in VO_2 — •Johannes M. Braun[1,2], Harald Schneider[1], Manfred Helm[1,2], Rafał Mirek[3], Lynn A. Boatner[4], Robert E. Marvel[5], Richard F. Haglund[5], and Alexej Pashkin[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]TU Dresden, Germany — [3]University of Warsaw, Poland — [4]Oak Ridge National Laboratory, USA — [5]Vanderbilt University, Nashville, USA

We utilize ultrafast optical pump – THz probe spectroscopy in order to investigate the pressure-driven insulator-to-metal transition (IMT) in vanadium dioxide (VO_2). The probe pulses with central frequency of 30 THz enable a sensitive detection of the photoinduced metallization.

The threshold pump fluence necessary for generation of a metastable metallic phase has been systematically measured for pressures up to 19 GPa. Initial pressure application leads to a notable increase of the threshold fluence. This contrasts the thermally-driven IMT in VO_2 where it decreases on approaching the transition temperature. Above the IMT, that occurs at approximately 6–8 GPa, we observe a sharp drop of the threshold fluence. However, the clear threshold behavior characteristic for systems with cooperative electronic localization still

could be observed also in the metallic state up to the highest applied pressure.

Our results support a view of the pressure-induced IMT in VO_2 as a purely electronic bandwidth-driven Mott-Hubbard transition, that does not involve any change in the crystal structure.

TT 73.8 Thu 17:00 HSZ 304

Coherent Order Parameter Oscillations in the Ground State of the Excitonic Insulator Ta_2NiSe_5 — •Daniel Werdehausen[1,2], Tomohiro Takayama[1,2], Marc Höppner[1], Gelon Albrecht[1,2], Andreas W. Rost[1,2], Yangfan Lu[3], Dirk Manske[1], Hidenori Takagi[1,2], and Stefan Kaiser[1,2] — [1]Max Planck Institut für Festkörperforschung, Stuttgart, Germany — [2]Universität Stuttgart, Germany — [3]University of Tokyo, Japan

The excitonic insulator state is an intriguing correlated electron phase that consists of condensed excitons. However, its experimental identification has proven to be challenging, mainly because it is difficult to probe the coherence of a condensate directly. One possibility is the observation of a condensate's intrinsic collective modes, which are equivalent to the Higgs- and Goldstone modes in superconductors. Here we report strong evidence for the existence of an excitonic insulator state in Ta_2NiSe_5: Using non-linear excitations with short laser pulses we identify a phonon-coupled state of the exciton condensate, in which its electronic Higgs-mode couples to a low frequency phonon [1]. The Higgs-mode contribution substantiates the picture of an electronically driven phase transition and can be used to characterize the transient order parameter of the excitonic insulator as a function of temperature and excitation density.

[1] D. Werdehausen et al. arxiv:1611.01053 (2016).

TT 73.9 Thu 17:15 HSZ 304

Real-time broadening of non-equilibrium density profiles and the role of the specific initial-state realization — •Robin Steinigeweg[1], Fengping Jin[2], Daniel Schmidtke[1], Hans De Raedt[3], Kristel Michielsen[2,4], and Jochen Gemmer[1] — [1]University Osnabrück — [2]Forschungszentrum Jülich — [3]University Groningen — [4]RWTH Aachen University

The real-time broadening of density profiles starting from non-equilibrium states is at the center of transport in condensed-matter systems and dynamics in ultracold atomic gases. Initial profiles close to equilibrium are expected to evolve according to linear response, e.g., as given by the current correlator evaluated exactly at equilibrium. Significantly off equilibrium, linear response is expected to break down and even a description in terms of canonical ensembles is questionable. We unveil [1] that single pure states with density profiles of maximum amplitude yield a broadening in perfect agreement with linear response, if the structure of these states involves randomness in terms of decoherent off-diagonal density-matrix elements. While these states allow for spin diffusion in the XXZ spin-1/2 chain at large exchange anisotropies, coherences yield entirely different behavior.

[1] R. Steinigeweg et al., arXiv:1610.05778 (2016).

TT 73.10 Thu 17:30 HSZ 304

Time evolution of two holes in $t-J$ chains with anisotropic couplings — •Salvatore R. Manmana[1], Holger Thyen[1], Thomas Köhler[1], and Stephan C. Kramer[1,2] — [1]Institut f. Theoretische Physik, U. Göttingen — [2]Fraunhofer ITWM Kaiserslautern

Using time-dependent Matrix Product State (MPS) methods we study the real-time evolution of hole-excitations in $t-J$ chains close to filling $n=1$. The dynamics in 'standard' $t-J$ chains with SU(2) invariant spin couplings is compared to the one when introducing anisotropic, XXZ-type spin interactions as realizable, e.g., by ultracold polar molecules on optical lattices. The simulations are performed with MPS implementations based on the usual singular value decompositions (SVD) as well as ones using the adaptive cross approximation (ACA) instead. The ACA can be seen as an iterative approach to SVD which is often used, e.g., in the context of finite-element-methods, leading to a substantial speedup. A comparison of the performance of both algorithms in the MPS context is discussed.

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TT 73.11 Thu 17:45 HSZ 304

Time-resolved correlation functions of the BEC/BCS crossover from many-body Ramsey interferometry — •Johannes Oberreuter[1], Henning Moritz[2], and Michael Knap[1] — [1]Department of Physics, Walter Schottky Institute and Institute for Advanced Study, Technical University of Munich, 85748 Garching, Germany — [2]Institut für Laserphysik, University of Hamburg, 22761 Hamburg, Germany

We propose a local and time-resolved probe to study the BEC/BCS crossover. The protocol is based on Ramsey interferometry between the two participating hyperfine states. We study rotations within the spin components as the third level typically suffers from increased loss. While on the BEC side the local spatial resolution cannot resolve the tightly bound molecules, on the BCS side as well as near unitarity we obtain dynamical information about the relevant scales.