DY 6: Many-Body Quantum Systems (joint session DY/TT)

Time: Monday 10:00–12:15 Location: ZEU 118

DY 6.1 Mon 10:00 ZEU 118

Localization in the non-interacting central site model and logarithmic entanglement growth — •Daniel Hetterich[1], Maksym Serbyn[2], Fernando Domínguez[1], Frank Pollmann[3], and Björn Trauzettel[1] — [1]Institut für Theoretische Physik, Universität Würzburg, D-97074 Würzburg, Germany — [2]Department of Physics, University of California, Berkeley, California 94720, USA — [3]Max-Plank Institute for the Physics of Complex Systems, D-0118 Dresden, Germany

We present both numerical and analytical results on localization features in the non-interacting central site model. Although this model is highly non-local – the central site couples equally to all other sites – we find exponentially localized eigenstates for all strengths of the coupling to the central site. Furthermore, the statistics of the corresponding wave functions show multifractality. Due to the special topology of our model, the entanglement entropy of factorized initial states grows logarithmically in time, which was previously thought to be present only in interacting many-body localized systems. This behavior can be analytically understood by the logarithmic motion of particles through the lattice.

DY 6.2 Mon 10:15 ZEU 118

Necessity of eigenstate thermalization for equilibration towards unique expectation values when starting from generic initial states — •Christian Bartsch and Jochen Gemmer — Fachbereich Physik, Universität Osnabrück, Barbarastraße 7, D-49069 Osnabrück

We investigate dynamical equilibration of expectation values in closed quantum systems for realistic non-equilibrium initial states. Thereby we find that the corresponding long time expectation values depend on the initial expectation values if eigenstate thermalization is violated. An analytical expression for the deviation from the expected ensemble value is derived for small displacements from equilibrium. Additional numerics for magnetization and energy equilibration in an asymmetric anisotropic spin-1/2-ladder demonstrate that the analytical predictions persist beyond the limits of the theory. The results suggest eigenstate thermalization as physically necessary condition for initial state independent equilibration.

DY 6.3 Mon 10:30 ZEU 118

Magnus expansion approach to parametric oscillator systems in a thermal bath — •Beilei Zhu — Zentrum für Optische Quantentechnologien and Institut für Laserphysik, Universität Hamburg, 22761 Hamburg, Germany

We develop a Magnus formalism for periodically driven systems which provides an expansion both in the driving term and the inverse driving frequency, applicable to isolated and dissipative systems. We derive explicit formulas for a driving term with a cosine dependence on time, up to fourth order. We apply these to the steady state of a classical parametric oscillator coupled to a thermal bath, which we solve numerically for comparison. Beyond dynamical stabilization at second order, we find that the higher orders further renormalize the oscillator frequency, and additionally create a weakly renormalized effective temperature. The renormalized oscillator frequency is quantitatively accurate almost up to the parametric instability, as we confirm numerically. Additionally, a cut-off dependent term is generated, which indicates the break-down of the hierarchy of time scales of the system, as a precursor to the instability. Finally, we apply this formalism to a parametrically driven chain, as an example for the control of the dispersion of a many-body system.

DY 6.4 Mon 10:45 ZEU 118

Experimentally accessible witnesses of many-body localisation — •Marcel Goihl[1], Mathis Friesdorf[1], Albert H. Werner[2], Winton Brown[1], and Jens Eisert[1] — [1]Freie Universität Berlin — [2]University of Copenhagen

The phenomenon of many-body localised (MBL) systems has attracted significant interest in recent years, for its intriguing implications from a perspective of both condensed-matter and statistical physics: they are insulators even at non-zero temperature and fail to thermalise, violating expectations from quantum statistical mechanics. What is more, recent seminal experimental developments with ultra-cold atoms in optical lattices constituting analog quantum simulators have pushed many-body localised systems into the realm of physical systems that can be measured with high accuracy. In this work, we introduce experimentally accessible witnesses that directly probe distinct features of MBL, distinguishing it from its Anderson counterpart. We insist on building our toolbox from techniques available in the laboratory, including on-site addressing, super-lattices, and time-of-flight measurements, identifying witnesses based on fluctuations, density-density correlators, densities, and entanglement. We build upon the theory of out of equilibrium quantum systems, in conjunction with tensor network and exact simulations, showing the effectiveness of the tools for realistic models.

DY 6.5 Mon 11:00 ZEU 118

Dynamics of correlations in long-range quantum systems following a quantum quench — •Lorenzo Cevolani[1], Giuseppe Carleo[2], and Laurent Sanchez-Palencia[3] — [1]Georg-August-Universität, Göttingen — [2]ETH, Zurich — [3]Laboratoire Charles Fabry. France

We study how and how fast correlations can spread in a quantum system abruptly driven out of equilibrium by a quantum quench. This protocol can be experimentally realized and it allow to address fundamental questions concerning the quasi-locality principle in isolated quantum systems with both short- and long-range interactions. We focus on two different models describing, respectively, lattice bosons, and spins. Our study is based on a combined approach, based on one hand on accurate many-body numerical calculations and on the other hand on a quasi-particle microscopic theory. We find that, for sufficiently fast decaying interaction potential the propagation is ballistic and the Lieb-Robinson bounds for long-range interactions are never attained. When the interactions are really long-range, the scenario is completely different in the two cases. In the bosonic system the locality is preserved and a ballistic propagation is still present while in the spin system an instantaneous propagation of correlations completely destroys locality. Using the microscopic point of view we can quantitatively describe all the different regimes, from instantaneous to ballistic, found in the spin model and we explain how locality is protected in the bosonic model leading to a ballistic propagation.

15 min. break

DY 6.6 Mon 11:30 ZEU 118

Direct observation of electronic, spin and charge separation in the ultrafast dynamics of $LaCoO_3$ — •Manuel Izquierdo[1,2], Alexander Yaroslavtsev[1,2], Robert Carley[1], Michael Karolak[3,2], Alexander Lichtenstein[2,1,4], Andreas Scherz[1], and Serguei Molodtsov[1,5,6] — [1]European XFEL GmbH, Albert-Einstein-Ring 19, 22761 Hamburg, Germany — [2]Institut für Theoretische Physik, Universität Hamburg, Jungiusstraße 9, 20355 Hamburg, Germany — [3]Theoretical Physics I, University of Würzburg, Am Hubland, 97074 Würzburg — [4]Ural Federal University, 620990 Yekaterinburg, Russia — [5]Institute of Experimental Physics, Technische Universität Bergakademie Freiberg, 09599 Freiberg, Germany — [6]ITMO University, Kronverkskiy pr. 49, 197101 St. Petersburg, Russia

The semiconductor to metal transition of $LaCoO_3$ (LCO) is investigated with all-optical and optical-soft x-ray pump-probe experiments performed with different time resolution. Picosecond studies have demonstrated the formation of a laser-induced transient metallic state. All-optical studies with femtosecond resolution have shown an ultrafast excitation of the system within a few hundred fs. Finally, spectroscopic studies with soft x-ray femtoslicing pulses have unraveled the properties of the transient metallic state, in which the electronic, spin and lattice degrees of freedom are excited on different time scales, demonstrating the relevance of soft x-ray femtosecond sources to investigate correlated systems.

DY 6.7 Mon 11:45 ZEU 118

Dissipation-induced enhancement of quantum fluctuations — •Gianluca Rastelli — University of Konstanz Fachbereich Physik, Fach 703 D-78457 Konstanz

We study a quantum harmonic oscillator linearly coupled through the position operator q to a first bath and through the momentum operator p to a second bath. We analyse the oscillator's fluctuations as a function of the ratio between the strength of the two couplings, focusing in particular on the situation in which the two dissipative interactions are comparable. Analytic formulas are derived in the low temperature limit [1]. In this regime, each bath operates to suppress the oscillator's ground state quantum fluctuations for q or p, viz. the operator appearing in the corresponding interaction. When one of the two dissipative interactions dominates over the other, the fluctuations for the coupling operator are squeezed. When the two interactions are comparable, the two baths enter in competition as the two conjugate operators do not commute yielding quantum frustration. In this regime, remarkably, the fluctuations of both two quadratures are enhanced by increasing the dissipative coupling. [1] G. Rastelli, New J. Phys. 18, 053033 (2016).

DY 6.8 Mon 12:00 ZEU 118

Dynamics of correlations in strongly interacting systems at finite temperatures — •Friedemann Queisser[1], Konstantin Krutitsky[1], Patrick Navez[2], and Ralf Schützhold[1] — [1]Fakultät für Physik, Universität Duisburg-Essen, Lotharstraße, Duisburg 47048, Germany — [2]Department of Physics, University of Crete, 71003 Heraklion, Greece

We discuss equilibrium and non-equilibrium properties of the Bose-Hubbard model in the formal limit of large coordination numbers Z [1]. Via an expansion of the correlation functions in powers of $1/Z$ we establish a hierarchy of correlations which facilitates the analysis of the system in equilibrium and in non-equilibrium. With this method we study the quantum dynamics (starting in a thermal state) after a quantum quench in the Mott (or normal gas) phase. The spread of correlations leads to an effective light-cone structure which depends sensitively on the initial thermal distribution [2].

[1] P. Navez and R. Schützhold, Phys. Rev. A **82**, 063603 (2010)

[2] K. V. Krutitsky, P. Navez, F. Queisser and R. Schützhold, EPJ Quantum Technology **1** (2014)