TT 4: Dynamics in many-body systems: Equilibriation and localization (Joint session of DY and TT organized by DY)

Time: Monday 9:30–12:45 Location: H47

TT 4.1 Mon 9:30 H47

Dynamical thermalization in Bose-Hubbard systems — •Peter Schlagheck[1] and Dima L. Shepelyansky[2] — [1]Département de Physique, Université de Liège, Belgium — [2]Laboratoire de Physique Théorique du CNRS, IRSAMC, Université de Toulouse UPS, France

A bosonic many-body system can exhibit the Bose-Einstein distribution in its single-particle eigenstates not only if it is coupled to a heat and particle reservoir, but also if it is subject to a two-body interaction of moderately low strength which couples the single-particle eigenstates with each other. We numerically verify this dynamical thermalization conjecture within disordered Bose-Hubbard rings of finite size whose parameters are chosen such that the dynamics of the system can be expected to be ergodic [1]. This allows one to associate with each many-body eigenstate of the Bose-Hubbard system well-defined (positive or negative) values for the effective temperature and the effective chemical potential which depend on the energy per particle of the eigenstate under consideration [1]. With this information one can then predict the populations of single-particle eigenmodes within each many-body eigenstate of the system according to the Bose-Einstein distribution, without knowing more details about the quantum dynamics of the many-body system.

[1] P. Schlagheck and D. L. Shepelyansky, arXiv:1510.01864.

TT 4.2 Mon 9:45 H47

Stationary state after a quench to the Lieb-Liniger from rotating BECs — •Leda Bucciantini — Max Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany

We study long-time dynamics of a bosonic system after suddenly switching on repulsive delta-like interactions. As initial states, we consider two experimentally relevant configurations: a rotating BEC and two counter-propagating BECs with opposite momentum, both on a ring. In the first case, the rapidity distribution function for the stationary state is derived analytically and it is given by the distribution obtained for the same quench starting from a BEC, shifted by the momentum of each boson. In the second case, the rapidity distribution function is obtained numerically for generic values of repulsive interaction and initial momentum. The significant differences for the case of large versus small quenches are discussed.

TT 4.3 Mon 10:00 H47

Short time propagation in interacting bosonic systems — •Benjamin Geiger, Quirin Hummel, Juan-Diego Urbina, and Klaus Richter — Institut für Theoretische Physik Universität Regensburg, 93040 Regensburg, Germany

We present a formalism to calculate thermodynamic properties of interacting bosonic gases as well as the smooth (Weyl) contribution to density of states by means of short-time propagation, and compare its analytical predictions against quantum integrable models. As an essential input of our approach, we were able to construct the many-body propagator for a one-dimensional unconfined bosonic gas with delta interactions of variable strength. Using this propagator we can give short-time approximations for the Lieb-Liniger model and non-integrable systems including external harmonic potentials. Furthermore we can think of using the spatial information and the time dependence of the propagator to calculate e.g. two-point correlations or to investigate quantum quenches.

TT 4.4 Mon 10:15 H47

Equilibration in many-body localised systems — Mathis Friesdorf, Albert Werner, •Marcel Goihl, Winton Brown, and Jens Eisert — Freie Universität Berlin

The effect of many-body localisation (MBL) is connected to an intriguing class of systems that fail to thermalise. Due to the randomness present in these models, both particles and energies remain largely confined to local regions. This prevents the relaxation of excitations and thus leads to a local memory of the precise initial conditions even after long evolution times. Based on a phenomenological model of MBL, we examine the time evolution of these systems and explore the role of local constants of motion, which are intrinsically present if energy is localised. We show that despite the fact that particles and energy are localised, information is able to propagate over arbitrary distances. Following this information theoretical viewpoint, we capture equilibration in MBL systems and derive time scales thereof. We connect our findings to signatures measurable in optical lattice architectures, thus allowing for the distinction of Anderson localisation and true MBL based solely on existing measurement techniques.

TT 4.5 Mon 10:30 H47

The eigenstate thermalization hypothesis as driving force behind initial state independent equilibration in closed quantum systems — •Christian Bartsch and Jochen Gemmer — Fachbereich Physik, Universität Osnabrück, Barbarastraße 7, D-49069 Osnabrück

We analyze the long time behavior of non-equilibrium expectation value dynamics for finite closed quantum systems considering very general Hamiltonians and observables. For a certain class of generic, i.e., experimentally realistic, initial states we analytically find that the long time expectation value depends on the concrete initial state and in general deviates from the expected average equilibrium value unless the eigenstate thermalization hypothesis (ETH) is fulfilled. We call this behavior stick effect. The initial states may be prepared by exposition of the system to a super bath in combination with an additional potential which depends on the regarded observable, thus the system is explicitly out of equilibrium and the initial state is correlated with both the Hamiltonian and the observable, i.e., the situation is not covered by established investigations involving typicality in terms of the Haar measure. The results suggest that the ETH may serve not only as a sufficient but also as a necessary condition for initial state independent equilibration. Numerics for a specific class of integrable quantum magnets, which does not fulfill the ETH, illustrate the findings.

TT 4.6 Mon 10:45 H47

Fluctuations, meta-stability and symmetry-breaking in open many-body systems — •Henrik Wilming[1], Albert H. Werner[1], Jens Eisert[1], and Michael J. Kastoryano[2] — [1]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin, Germany — [2]NBIA, Niels Bohr Institute, University of Copenhagen, 2100 Copenhagen, DK

It is known that finite fluctuations of densities in thermal states correspond to the existence of several phases. In the case of fluctuations in order-parameters, they lead to the existence of spontaneous symmetry-breaking. Such results are purely kinematic in that they do not show how these states are prepared by nature.

Here, we consider the corresponding dynamical question: We assume that a state with finite fluctuations in a density is prepared by a dissipative Markovian short-range dynamics that is in detailed balance and show that such dynamics necessarily also has different meta-stable states, which converge to steady-states on (quasi-)local observables in the thermodynamic limit. In the case of fluctuating order-parameters we show the existence of explicitly symmetry-breaking meta-stable states and construct dissipative Goldstone-modes on top of them.

The existence of such meta-stable states shows that it is inherently difficult to prepare a many-body state with strong long-range correlations by short-range dissipative processes fulfilling detailed balance. Our results hold on regular lattices in arbitrary spatial dimensions and are constructive in the sense that we explicitly write down the meta-stable states.

15 min. break

TT 4.7 Mon 11:15 H47

Approaching equilibrium: Fermionic Gaussification — •Marek Gluza[1], Christian Krumnow[1], Mathis Friesdorf[1], Christian Gogolin[2,3], and Jens Eisert[1] — [1]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, Berlin, Germany — [2]ICFO-The Institute of Photonic Sciences, Mediterranean Technology Park, Barcelona, Spain — [3]Max-Planck-Institut für Quantenoptik, Garching, Germany

When and by which mechanism do closed quantum many-body systems equilibrate? This fundamental question lies at the very basis of the connection between thermodynamics, many-body quantum mechanics and condensed matter theory. In the setting of free fermionic evolutions, we rigorously capture the time evolution in abstract terms and uncover the underlying mechanism how local memory of the initial conditions is forgotten. Specifically, starting from an initially short range correlated fermionic states which can be very far from Gaussian, we show that if the Hamiltonian provides sufficient transport, the system approaches a state that locally cannot be distinguished from a corresponding Gaussian state. In this way, strongly correlated states, as encountered in the Fermi-Hubbard model, will become locally Gaussian during the evolution under a hopping Hamiltonian, leading to density-density correlations that factor according to Wick's theorem. For experimentally relevant instances of ultra-cold fermions in optical lattices, our result implies equilibration on realistic physical time scales. Moreover, we characterise the equilibrium state, finding an instance of a rigorous convergence to a Generalized Gibbs ensemble.

TT 4.8 Mon 11:30 H47

Controlling Fluctuations in Parametrically Driven Oscillators and Lattices — •Beilei Zhu and Ludwig Mathey — ZOQ/ILP, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

We consider an oscillator parametrically and periodically driven at a high frequency . In the quantum limit we obtain an effective Hamiltonian in the interaction picture analytically via Magnus Expansion. We compare this analytical result with a numerical one, which is developed in the classic limit in the Langevin formalism. The simulation results show that the fluctuations of the oscillator coordinates are reduced at high driving frequencies and moderate driving amplitudes. We also obtain qualitatively similar results in a lattice of parametric oscillators.

TT 4.9 Mon 11:45 H47

Equilibration of isolated quantum systems due to restrictions in the experimental set-up — •Ben Niklas Balz — Bielefeld University, Germany

We will explore in what sense and under which conditions isolated quantum many-body systems equilibrate. To estimate the deviations from the equilibrium state a more realistic distinguishability measure than the ones used in [1,2] will be developed, taking into account how often observables with a certain set of outcomes are measured. As a consequence new insights which physical parameters influence equilibration dynamics in what way can be gained. This might be of theoretical importance contributing to the understanding of thermalization [3] or can be used to give more accurate bounds on equilibration times [4,5].

[1]Peter Reimann. Physica Scripta, 86(5), 2012.
[2]Anthony J Short. New Journal of Physics, 13(5):053009, 2011.
[3]Peter Reimann. New Journal of Physics, 17(5):055025, 2015.
[4]D. Hetterich, M. Fuchs, and B. Trauzettel. ArXiv, June 2015.
[5]L. P. Garcia-Pintos, N. Linden, A. S. L. Malabarba, A. J. Short, and A. Winter. ArXiv e-prints, September 2015.

TT 4.10 Mon 12:00 H47

Reduced fluctuations in dissipative parametric oscillators — •Tobias Rexin, Beilei Zhu, and Ludwig Mathey — Zentrum für Optische Quantentechnologien und Institut für Laserphysik, Universität Hamburg, 22761 Hamburg, Germany

In this work we describe the non-equilibrium effects of a dissipative parametric oscillator system for which we derive an effective time-independent Hamiltonian via Magnus Expansion. The analytical result shows reduced variance in the high driving frequency and moderate driving amplitude regime, which also coincides with numerical results from the Langevin Equations. A chain of parametric oscillators exhibits similiar behavior.

TT 4.11 Mon 12:15 H47

Time evolution of the electron distribution function of thin copper films probed with broadband femtosecond optical pulses — •Manuel Obergfell and Jure Demsar — Universität Mainz

The time-resolved dynamics of the optical constants of thin copper films has been measured in the visible range. The photoinduced changes in reflectivity and transmission are based on the changes to the electron distribution function at the Fermi level. The dielectric function of copper is modelled at the d-band to Fermi level transition at photon energies up to 3 eV. With a low amount of sample dependent parameters the matching to the temperature dependence of the dielectric function of copper is achieved. Therefore we can reproduce standard thermomodulation. To extract the electron distribution function time dependently, the deconvolution is performed by matrix inversion. Our results demonstrate a highly non-thermal electronic distribution up to time delays of more than 1 ps depending on excitation density, at odds with the Two-Temperature model assumption. We extract the electron-phonon coupling constant from these data and compare the results to several recent theoretical models.

TT 4.12 Mon 12:30 H47

Adsorption-desorption kinetics of soft particles onto surfaces — •Brendan Osberg and Ulrich Gerland — Complex Biosystems, Physik-Department, Technische Universitaet Muenchen, Garching, Germany

A broad range of physical, chemical, and biological systems feature processes in which particles randomly adsorb on an extended substrate. Theoretical models usually assume hard (mutually impenetrable) particles, but in soft matter physics the adsorbing particles can be effectively compressible, implying soft interaction potentials. We recently studied the kinetics of such soft particles adsorbing onto one-dimensional substrates, identifying three novel phenomena: (i)gradual density increases, or 'cramming', replaces the usual jamming behavior seen in hard particles, (ii) a density overshoot can occur (only for soft particles) on a time scale set by the desorption rate, and (iii) relaxation rates of soft particles increase with particle size (on a lattice), while hard particles show the opposite trend. The latter occurs since unjamming requires desorption and many-bodied reorganization to equilibrate -a process that is generally very slow. Here we extend this analysis to a two-dimensional substrate, focusing on the question of whether the adsorption-desorption dynamics of particles in two dimensions are similarly enriched by the introduction of soft interactions. Application to experiments, for example the adsorption of fibrinogen on two-dimensional surfaces, will be discussed.