TT 22: Many-body Systems: Equilibration, Chaos, and Localization (joint session DY/TT)

Time: Tuesday 14:00–15:30 Location: H37

TT 22.1 Tue 14:00 H37

Power-law banded random matrices as models for quantum many-body Hamiltonians — •Wouter Buijsman[1], Masudul Haque[2,1], and Ivan M. Khaymovich[3] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]TU Dresden, Institute of Theoretical Physics, Dresden, Germany — [3]Nordita, Stockholm, Sweden

Hamiltonians of one-dimensional, disordered single-particle sytems with long-range hoppings can naturally be modeled by power-law banded random matrices. In this picture, the phase diagram of power-law banded random matrices show an ergodic, weakly ergodic, and localized phase. Motivated by modern developments on ergodicity breaking and localization in interacting quantum many-body systems, we study many-body interpretations of such random matrices. We discuss a number of ways to label the basis states with many-body configurations, and compare the physical properties of the resulting Hamiltonians. Specifically, we study the scaling of the many-body entanglement entropy with system size for eigenstates at both the bulk and the edge of the spectra. Using a scaling analysis on the full sets of eigenstates, we subsequently provide a quantitative picture of the phase diagram. We elaborate on the physical relevance of this interpretation of random matrix models for quantum many-body systems.

TT 22.2 Tue 14:15 H37

Escaping the Krylov space during reorthogonalization — •Max Pieper, Jannis Eckseler, and Jürgen Schnack — Universität Bielefeld

Krylov complexity [1] is often used as a measure of complexity in quantum many-body-systems. During its calculation, the Lanzcos algorithm is used to construct an operator basis. Due to the poor orthogonality of the resulting basis reorthogonalization is often employed [2]. We investigate how using reorthogonalization causes the Lanczos algorithm to accumulate non-Krylov basis elements. We suspect this to negatively affect the Krylov algorithm.

[1] D. E. Parker et al. Phys. Rev. X 9, 041017 (2019)
[2] E. Rabinovici et al. JHEP 06, 062 (2021)

TT 22.3 Tue 14:30 H37

An estimate of the equilibration time based on the operator growth hypothesis — •Merlin Füllgraf, Jiaozi Wang, and Jochen Gemmer — Universität Osnabrück

We study the equilibration times T_{eq} of local observables in quantum chaotic systems by considering their auto-correlation functions. Based on the recursion method, we suggest a scheme to estimate T_{eq} from the corresponding Lanczos coefficients. We numerically find that, if an observable follows the *operator growth hypothesis*, a finite number of Lanczos coefficients is sufficient for a reasonable estimate of the equilibration time. This implies that equilibration occurs on a realistic time scale much shorter than the life of the universe. The numerical findings are further supported by analytical arguments.

TT 22.4 Tue 14:45 H37

Effects of chaos in Bose-Hubbard systems with few degrees of freedom. The smallest possible heat engine? — •Viviane Bauer, Nico Fink, and James Anglin — Physics Department and Research Center OSCAR, RPTU Kaiserslautern-Landau

Microscopic engines are a research focus in both biochemistry and nanotechnology. While other forms of engines besides heat engines are also being considered, the fully microscopic limit of a heat engine is a fundamentally important problem in physics. What happens to thermodynamics when not only the working fluid and mechanism of a heat engine, but even the hot and cold reservoirs are microscopic?

To realize such microscopic heat baths, we turn to the process of chaotic ergodization, studied in Bose-Hubbard dimers and trimers.

One realization we currently study is based on two Bose-Hubbard trimers, which allow energy and particle transport between them. The particle transport is furthermore coupled to a mass, so our engine works against a force to lift it. Moreover, we have identified a dynamic mechanism which can stabilize this lifting process. The result is a system which operates just like a heat engine, except for being fully microscopic. The structure of coupled chaotic subsystems both supports and requires an understanding of the fully microscopic heat engine in terms of open-system control.

TT 22.5 Tue 15:00 H37

Impurity coupled to the SYK bath — •Anastasia Enckell and Stefan Kehrein — Institute for Theoretical Physics, Georg-August-Universität Göttingen, Germany

System-plus-bath models play an important role in addressing fundamental questions in condensed matter physics. One challenging aspect is modelling the bath, which is often approached using free-particle or open quantum system frameworks. Here, we explore the Sachdev-Ye-Kitaev (SYK) model as a new kind of quantum bath with unique properties, including the absence of quasiparticles, maximal chaos, and non-integrability, which make it a valuable framework for studying system-plus-bath interactions. We study the time evolution of the occupation of an impurity coupled to the SYK bath following a quench. From the Kadanoff-Baym equations for a noninteracting impurity, we see that the only relevant property for the impurity occupation is a combination of hybridisation and density of states of the bath. These parameters can be adjusted in order to model the impurity coupled to any bath of interest. Using this approach, we can study the impurity dynamics coupled to the SYK bath by making suitable changes to the hybridisation in impurity plus Fermi bath setting, which significantly simplifies the task. We observe oscillatory dynamics of the impurity at zero temperature, with the oscillations decreasing as the temperature increases. This behaviour contrasts with that of a free-particle bath and suggests interesting underlying physics.

TT 22.6 Tue 15:15 H37

Thermal-relaxation asymmetry in fluctuating hydrodynamics — •Felipe Pereira-Alves and Aljaž Godec — Mathematical bioPhysics Group, Max Planck Institute for Multidisciplinary Sciences, 37077 Göttingen, Germany

It was theoretically predicted and recently experimentally confirmed that small systems, such as trapped colloidal particles quenched far from equilibrium, heat up faster than they cool down. The phenomenon was coined thermal-relaxation asymmetry. The proposed physical explanation of the asymmetry instigated intriguing questions about its existence in the thermodynamic limit. Here we investigate thermal relaxation dynamics in far-from-equilibrium temperature quenches on the level of fluctuating hydrodynamics of short- and long-range (logarithmically) interacting many-body systems. We prove the existence of a strict asymmetry for any temperature quench for both, short- and long-range interactions. Remarkably, in contrast to small systems, there is no “close-to-equilibrium” regime of quenches for which heating and cooling are symmetric. Notably, we find that relaxation is self-similar up to the relaxation time, and uncover intricate differences between short- and long-range interactions.