DY 66: Many-body Quantum Dynamics II

Time: Friday 10:00–12:00 Location: HÜL 186

DY 66.1 Fri 10:00 HÜL 186

Light Induced Electron Superconductivity with Driven Optical Cavity — •Ahana Chakraborty and Francesco Piazza — Max Planck Institute for Physics of Complex Systems, Dresden, Germany

In a recent work, Schlawin et. al. [PRL, 122, 133602 (2019)] studied the possibility to induce superconductivity via cavity-mediated electron-electron interactions. This cavity-induced 'Amperean' pairing, which involves electrons propagating in the same direction, with total centre-of-mass momentum on the Fermi surface is estimated to lead to superconductivity in the low kelvin-regime for GaAs using realistic cavity parameters. In our work, we investigate the possibility of stabilising the superconducting state at even higher temperatures by driving the optical cavity. The effect of loss of photons as well as incoherent pump is incorporated by non- equilibrium field theoretic techniques, which also allow us to explore beyond the weak coupling regime of the electrons and the cavity.

DY 66.2 Fri 10:15 HÜL 186

Quantum Many-Body Scars in Doubly Modulated Optical Lattices — •Hongzheng Zhao[1], Joseph Vovrosh[1], Florian Mintert[1], and Johannes Knolle[1,2] — [1]Blackett Laboratory, Imperial College London, London, United Kingdom — [2]Department of Physics, Technische Universitt Mnchen, Garching, Germany

The concept of quantum many-body scars has recently been introduced to explain the weak ergodicity breaking experimentally observed in a Rydberg atom platform. There, exceptionally long coherent oscillations are observed for quenches from a set of special initial states. Such scared eigenstates, which are concentrated in a small fragment of the total Hilbert space, have been discovered theoretically in a number of spin and fermionic models. Here, we propose a simple setup to generate quantum many-body scars in a doubly modulated Bose-Hubbard system which can be readily implemented in cold atomic gases. In the high frequency limit, we show that the dynamics is governed by density assisted tunneling. We find the optimal driving parameters for the kinetically constrained hopping which leads to small isolated subspaces of scared eigenstates. We discuss the experimental signatures and analyze the transition to fully thermalizing behavior as a function of driving frequency.

DY 66.3 Fri 10:30 HÜL 186

Higher-order and fractional discrete time crystals in clean long-range interacting systems — •Andrea Pizzi[1], Johannes Knolle[2,3,4], and Andreas Nunnenkamp[1] — [1]Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, United Kingdom — [2]Department of Physics, Technische Universität München, James-Franck-Straße 1, D-85748 Garching, Germany — [3]Munich Center for Quantum Science and Technology (MCQST), 80799 Munich, Germany — [4]Blackett Laboratory, Imperial College London, London SW7 2AZ, United Kingdom

Discrete time crystals are periodically driven systems characterized by a response with periodicity nT, with T the period of the drive and $n > 1$. Typically, n is an integer and bounded from above by the dimension of the local (or single particle) Hilbert space, the most prominent example being spin-1/2 systems with n restricted to 2. Here we show that a clean spin-1/2 system in the presence of long-range interactions and transverse field can sustain a huge variety of different 'higher-order' discrete time crystals with integer and, surprisingly, even fractional $n > 2$. We characterize these non-equilibrium phases of matter thoroughly using a combination of exact diagonalization, semiclassical methods, and spin-wave approximations, which enable us to establish their stability in the presence of competing long- and short-range interactions. Remarkably, these phases emerge in a model with continous driving and time-independent interactions, convenient for experimental implementations with ultracold atoms or trapped ions.

DY 66.4 Fri 10:45 HÜL 186

Unitary long-time dynamics with quantum renormalization groups and Artificial Neural Networks — •Heiko Burau and Markus Heyl — Max Planck Institut für Physik komplexer Systeme, Dresden, Germany

The exponential growth of complexity in quantum mechanics limits, in general, the simulation of non-equilibrium dynamics in large closed systems to short or intermediate time scales. In this work we combine quantum renormalization group approaches with deep artificial neural networks (ANNs) for the description of the real-time evolution in strongly disordered quantum matter. We find that this allows us to accurately compute the long-time dynamics of many-body localized systems. Concretely, we use this approach to describe the spatioemporal buildup of many-body localized spin glass order in random Ising models.

DY 66.5 Fri 11:00 HÜL 186

Reinforcement Learning for Digital Quantum Simulation — •Adrien Bolens and Markus Heyl — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Digital quantum simulations (DQS) are one of the most appealing applications of a quantum computer. In theory, the unitary time-evolution of any spin-type Hamiltonian can be encoded in a quantum computer with arbitrary precision. In practice, however, unitary gates entangling different qubits are an important source of error. We use tailored reinforcement learning techniques to optimally generate DQS of collective quantum spin systems, such as the long-range Ising model and the XX model. We show that for a fixed number of entangling quantum gates, the DQS error found is systematically lower than the Trotter error, and decay much more slowly with the system size. In addition, our method let us generate efficient DQS even for models without a well-defined Trotterization in the quantum simulator. We discuss the implications of our algorithm for the implementation of DQS in trapped-ion quantum simulators.

DY 66.6 Fri 11:15 HÜL 186

Local correlations in dual kicked models — •Daniel Waltner[1], Boris Gutkin[2], Petr Braun[1], Maram Akila[3], and Thomas Guhr[1] — [1]Fakultät für Physik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany — [2]Department of Applied Mathematics, Holon Institute of Technology, 58102 Holon, Israel — [3]Fraunhofer-Institutszentrum Schloss Birlinghoven, Schloss Birlinghoven, 53754 Sankt Augustin

Recent studies [1] have demonstrated that two-point correlations of local operators in unitary-dual circuit lattices are restricted to light cone edges. We show that for a wide class of dual kicked chain systems, built upon a pair of complex Hadamard matrices, the l-point correlators of strictly local, traceless operators vanish identically in the thermodynamic limit. On the other hand, non-local operators, generically, exhibit nontrivial correlations along the light cone edges. We obtain an explicit, analytic form of two-point correlators for operators supported at pairs of adjacent chain sites.

[1] B. Bertini, P. Kos, T. Prosen, Phys. Rev. Lett. **123**, 210601 (2019).

DY 66.7 Fri 11:30 HÜL 186

Quantum scars of bosons with correlated hopping — •Ana Hudomal[1], Ivana Vasić[1], Nicolas Regnault[2,3], and Zlatko Papić[4] — [1]Scientific Computing Laboratory, Center for the Study of Complex Systems, Institute of Physics Belgrade, University of Belgrade, Serbia — [2]Joseph Henry Laboratories and Department of Physics, Princeton University, USA — [3]Laboratoire de Physique de l'École Normale Supérieure, ENS, CNRS, Paris, France — [4]School of Physics and Astronomy, University of Leeds, United Kingdom

Recent experiments have shown that preparing an array of Rydberg atoms in a certain initial state can lead to unusually slow thermalization and persistent density oscillations [1]. This type of non-ergodic behavior has been attributed to the existence of "quantum many-body scars", i.e., atypical eigenstates that have high overlaps with a small subset of vectors in the Hilbert space. Periodic dynamics and many-body scars are believed to originate from a "hard" kinetic constraint: due to strong interactions, no two neighbouring Rydberg atoms are both allowed to be excited. Here we propose a realization of quantum many-body scars in a 1D bosonic lattice model with a "soft" constraint: there are no restrictions on the allowed boson states, but the amplitude of a hop depends on the occupancy of the hopping site. We find that this model exhibits similar phenomenology to the Rydberg atom chain, including weakly entangled eigenstates at high energy densities and the presence of a large number of exact zero energy states [2].

[1] H. Bernien et al., Nature **551**, 579 (2017).
[2] A. Hudomal et al., arXiv:1910.09526 (2019).

DY 66.8 Fri 11:45 HÜL 186

How the energy structure of perturbations affects the relaxation of many-body quantum systems — •Lennart Dabelow and Peter Reimann — Fakultät für Physik, Universität Bielefeld, 33615 Bielefeld, Germany

We investigate the response of isolated many-body quantum systems to generic perturbations. In general, such perturbations will couple states of different energies differently, but commonly the strength depends dominantly on their energy distances. Under this assumption, and in the absence of specific symmetries or macroscopic inhomogeneities, we use typicality methods to derive an integral equation relating the energy profile of the perturbation to the temporal relaxation characteristic of the perturbed system. The solution of this equation leads to a prediction for the time evolution of observables. We illustrate the general results by means of specific examples.