QI 37: Quantum Many Body Systems

Time: Friday 14:30–16:15 Location: F428

QI 37.1 Fri 14:30 F428

Metastable discrete time-crystal resonances in a dissipative central spin system — •Albert Cabot[1], Federico Carollo[1], and Igor Lesanovsky[1,2] — [1]Institut für Theoretische Physik, Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany — [2]School of Physics and Astronomy and Centre for the Mathematics and Theoretical Physics of Quantum Non-Equilibrium Systems, The University of Nottingham, Nottingham, NG7 2RD, United Kingdom

We consider [1] the non-equilibrium behavior of a central spin system where the central spin is periodically reset to its ground state. The quantum mechanical evolution under this effectively dissipative dynamics is described by a discrete-time quantum map. Despite its simplicity this problem shows surprisingly complex dynamical features. In particular, we identify several metastable time-crystal resonances. Here the system does not relax rapidly to a stationary state but undergoes long-lived oscillations with a period that is an integer multiple of the reset period. At these resonances the evolution becomes restricted to a low-dimensional state space within which the system undergoes a periodic motion. Generalizing the theory of metastability in open quantum systems, we develop an effective description for the evolution within this long-lived metastable subspace and show that in the long-time limit a non-equilibrium stationary state is approached. Our study links to timely questions concerning emergent collective behavior in the "prethermal" stage of a dissipative quantum many-body evolution as well as to the phenomenon of quantum synchronization. [1] A. Cabot et al., Phys. Rev. B 106, 134311 (2022)

QI 37.2 Fri 14:45 F428

Haldane phase in one-dimensional systems of Rydberg atoms — •Johannes Mögerle and Hans Peter Büchler — Institute for Theoretical Physics III and Center for Integrated Quantum Science and Technology, University of Stuttgart, 70550 Stuttgart, Germany

Quantum many body physics features a wide range of interesting phenomena. This includes new, so-called topological quantum phases, which appear due to entanglement. One of the earliest proposed such phase is the Haldane phase in a one-dimensional Spin 1 chain, which later was found to be a symmetry protected topological phase. A promising platform to realize all kinds of topological phases are Rydberg atoms with their strong and tunable interactions.

This work focuses on numerically simulating the Haldane phase in a parameter regime which is accessible in Rydberg systems. Moreover, we are proposing a concrete example of experimental parameters using a three level system in Rubidium atoms to realize a groundstate close to the famous AKLT state.

QI 37.3 Fri 15:00 F428

Series expansions with multiple quasi-particle types for the dual Dicke-Ising model — •Andreas Schellenberger, Lea Lenke, and Kai Phillip Schmidt — FAU Erlangen-Nürnberg, Erlangen, Deutschland

The established approach of perturbative continuous unitary transformations (pCUT) constructs effective quantum many-body Hamiltonians in a perturbative series that conserve the number of one quasi-particle type. We extend the pCUT method to similarity transformations – dubbed pcst^{++} – allowing for multiple quasi-particle-types with complex-valued energies. This enlarges the field of application to closed and open quantum many-body systems with unperturbed operators corresponding to arbitrary superimposed ladder spectra. To illustrate the new possibility of the pcst^{++} method to specifically tackle interacting light-matter systems, we discuss the dual Dicke-Ising model. We determine low-energy spectral properties and investigate potential conversion processes between different quasi-particle types.

QI 37.4 Fri 15:15 F428

Reviving product states in the disordered Heisenberg chain — •Henrik Wilming[1], Tobias J. Osborne[1], Kevin S.C. Decker[2], and Christoph Karrasch[2] — [1]Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany — [2]Technische Universität Braunschweig, Institut für Mathematische Physik, Mendelssohnstraße 3, 38106

When a generic quantum system is prepared in a simple initial condition, it typically equilibrates toward a state that can be described by a thermal ensemble. A known exception are localized systems which are non-ergodic and do not thermalize, however local observables are still believed to become stationary. Here we demonstrate that this general picture is incomplete by constructing product states which feature periodic high-fidelity revivals of the full wavefunction and local observables that oscillate indefinitely. The system neither equilibrates nor thermalizes. This is analogous to the phenomenon of weak ergodicity breaking due to many-body scars and challenges aspects of the current MBL phenomenology, such as the logarithmic growth of the entanglement entropy. To support our claim, we combine analytic arguments with large-scale tensor network numerics for the disordered Heisenberg chain. Our results hold for arbitrarily long times in chains of 160 sites up to machine precision.

QI 37.5 Fri 15:30 F428

Linked-cluster expansions of perturbed topological phases — •Viktor Kott, Matthias Mühlhauser, and Kai Phillip Schmidt — FAU, Erlangen-Nürnberg, Deutschland

We investigate the robustness of Kitaev's toric code in a uniform magnetic field on the square and honeycomb lattice by perturbative linked cluster expansions using a full graph decomposition. In particular, the full graph decomposition allows to correctly take into account the non-trivial mutual exchange statistics of the elementary anyonic excitations. This allows us to calculate the ground-state energy and excitation energies of the topological phase which are then used to study the quantum phase transitions out of the topologically ordered phase as a function of the field direction.

QI 37.6 Fri 15:45 F428

Systematic Analysis of Diagonal Ordering Patterns in Bosonic Lattice Models with Algebraically Decaying Density-Density Interactions — •Jan Alexander Koziol[1], Antonia Duft[1], Giovanna Morigi[2], and Kai Phillip Schmidt[1] — [1]Department of Physics, Staudtstraße 7, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany — [2]Theoretical Physics, Saarland University, Campus E2.6, D-66123 Saarbrücken, Germany

We propose a general approach to analyse diagonal ordering patterns in bosonic lattice models with algebraically decaying density-density interactions on arbitrary lattices. The key idea is a systematic search for the energetically best order on all unit cells of the lattice up to a given extent. Using resummed couplings we evaluate the energy of the ordering pattern in the thermodynamic limit using finite unit cells. We apply the proposed approach to the atomic limit of the extended Bose-Hubbard on a triangular lattice at fillings $f = 1/2$ and $f = 1$. We investigate the ground-state properties of the antiferromagnetic long-range Ising model on the triangular lattice and determine a six-fold degenerate plain-stripe phase to be the ground state for finite decay exponents. We also probe the classical limit of the Hamiltonian describing Rydberg atom arrangements on the sites and links of the Kagome lattice.

QI 37.7 Fri 16:00 F428

Series expansions in open and non-Hermitian quantum many-body systems with multiple quasi-particle types — •Lea Lenke, Andreas Schellenberger, and Kai Phillip Schmidt — FAU Erlangen-Nürnberg

The established approach of perturbative continuous unitary transformations (pCUT) constructs effective quantum many-body Hamiltonians in a perturbative series that conserve the number of one quasi-particle type. We extend the pCUT method to similarity transformations – dubbed pcut^{++} – allowing for multiple quasi-particle-types with complex-valued energies. This enlarges the field of application to closed and open quantum many-body systems with unperturbed operators corresponding to arbitrary superimposed ladder spectra. To this end a generalized counting operator is combined with the quasi-particle generator for open quantum systems recently introduced by Schmiedinghoff and Uhrig [1]. The pcut^{++} then yields model-independent quasi-particle conserving effective Hamiltonians and Lindbladians allowing a linked-cluster expansion similar to the conventional pCUT method. We illustrate the application of the pcut^{++} method by discussing representative open and non-Hermitian quantum systems.

[1] G. Schmiedinghoff and G. S. Uhrig, "Efficient flow equations for dissipative systems", (2022), arXiv:2203.15532 [cond-mat.quant-ph].