DY 16: Quantum Dynamics, Decoherence and Quantum Information

Time: Tuesday 10:00–11:30 Location: H6

DY 16.1 Tue 10:00 H6

The dynamics of the Lindblad equation when including feedback from the environment — •Bernd Michael Fernengel and Barbara Drossel — Hochschulstraße 6, 64289 Darmstadt

The Lindblad equation describes the time evolution of an open quantum system when the environment relaxes fast. In addition to the von-Neumann term * describing the unitary time evolution according to the Schroedinger equation * the Lindblad equation takes into account stochastic transitions between different states. It assumes that the environment is not changed as the state of the system changes.

We abandon this last assumption and allow for an (instantaneous) feedback of the (mixed) state of the ensemble onto itself via the environment. One way to realize this would be to have several systems coupled to the same environment. This leads to a time evolution equation that is nonlinear in the density matrix. By using the example of a two-level system, we show explicitly that various types of instabilities and bifurcations can occur.

DY 16.2 Tue 10:15 H6

Lindblad equation for thermal environments beyond the rotating-wave approximation — •Tobias Becker, Lingna Wu, and André Eckardt — Max Planck Institute for the Physics of Complex Systems, Dresden

Many problems addressing open quantum systems (for weak system-bath coupling) start from a master equation in Lindblad form. In particular, it is needed for quantum trajectory simulations. For thermal environments, such a Lindblad-type master equation can be derived starting from the Redfield-equation (Born-Markov approximation) by applying a rotating-wave approximation. However, this approximation requires extremely weak system-bath coupling, which is small compared to the level splitting in the system. Here, we describe an alternative approximation to the Redfield equation, which also leads to a master equation in Lindblad form. It is valid also for larger system-bath coupling. We test our results using the example of a system of interacting bosons in a double well coupled to an Ohmic bath.

DY 16.3 Tue 10:30 H6

Entanglement via dissipation in a nonlinear circuit QED system — •Dominik Maile[1,2], Sabine Andergassen[1], Wolfgang Belzig[2], and Gianluca Rastelli[2] — [1]Eberhard Karls University, Tübingen, Germany — [2]University Konstanz, Konstanz, Germany

We discuss a superconducting nanoscale circuit formed by two microwave cavities coupled via a Josephson junction and a joint capacitance to the ground. In addition, the Josephson junction is shunted by a resistance and one plate of the capacitor is in series with a resistance connected to the ground. Such a configuration leads to dissipation in the relative phase difference across the Josephson junction and in the total charge of the two capacitances in parallel [1,2]. We show that, in the steady state, the resonators are in an entangled state and calculate the logarithmic negativity as a measure of entanglement in the harmonic regime. We find that the entanglement grows by increasing both dissipative coupling strengths via simultaneous squeezing of the fluctuations of the total charge and the relative phase difference. Due to the dissipative interaction, the system is not in a pure state. However, in the limit of large squeezing we compare the entanglement generated via dissipation with the one of an effective pure two-mode squeezed state. Increasing the coupling strength between the two oscillators via the Josephson energy also leads to a rise of the entanglement. Here the system enters the nonlinear coupling regime. We analyze the effect of such nonlinear interaction perturbatively.

[1] G. Rastelli, New Journal of Physics 18, 053033 (2016)
[2] D. Maile, et al. PRB 97, 155427 (2018)

DY 16.4 Tue 10:45 H6

Dephasing and relaxation of topological states in extended quantum Ising models — •Hannes Weisbrich, Wolfgang Belzig, and Gianluca Rastelli — Universität Konstanz

Inspired by recent progress in coupled arrays of qubits, we study the dephasing and relaxation dynamics of topological states in an extended class of quantum Ising chains of finite length [1]. We assume a local dephasing interaction of each spin with a local thermal bath, from which we derive a Lindblad equation. This kind of interaction preserves the parity in the system [2]. We demonstrate a correlation between the decoherence in the manyfold ground state subspace and the topology in the spin chain, characterized by a winding number g. In particular, in the topological regime and at low temperature, the decoherence rates can be exponentially suppressed. For the simple case of the transverse Ising model (g=1) this simply corresponds to the exponentially small overlap of the two localized Majorana zero energy modes of the equivalent Kitaev chain. We generalize this result in a chain with a three body, next nearest neighbor interaction (with g=2) in which the ground state subspace is fourfold degenerate with two ground states in each parity sector (even and odd), namely with four Majorana modes. For the second model, we analyze the decay rates and the probability of occupation of the different ground states as a function of the initial excited state.

[1] H. Weisbrich, W. Belzig, G. Rastelli (to be submitted);
[2] H. Weisbrich, C. Saussol, W. Belzig, G. Rastelli, Phys. Rev. A 98, 052109 (2018).

DY 16.5 Tue 11:00 H6

Engineering thermal reservoirs for ultracold dipole-dipole-interacting Rydberg atoms — David Schönleber, Chris Bentley, and •Alex Eisfeld — MPI-PKS Dresden

We consider an open quantum system of ultracold Rydberg atoms. The system part consists of resonant dipole-dipole-interacting Rydberg states. The environment part is formed by 'three-level atoms': each atom has a ground state, a short-lived excited state, and a Rydberg state that interacts with the system states. The two transitions in the environment atoms are optically driven, and provide control over the environment dynamics [1]. Appropriate choice of the laser parameters allows us to prepare a Boltzmann distribution of the system's eigenstates. By tuning the laser parameters and system-environment interaction, we can change the temperature associated with this Boltzmann distribution, and also the thermalization dynamics [2]. The correct parameters are obtained via machine-learning techniques [3]. Our method provides novel opportunities for quantum simulation of thermalization dynamics using ultracold Rydberg atoms.

[1] Phys. Rev. Lett. 114 123005 (2015) [2] New J. Phys. 20, 013011 (2018) [3] J. Phys. B 51, 205003 (2018)

DY 16.6 Tue 11:15 H6

Thermally assisted Thouless pumping in the Rice-Mele model — •Luca Arceci[1], Angelo Russomanno[2], and Giuseppe Santoro[1,2] — [1]SISSA, Via Bonomea 265, I-34136 Trieste, Italy — [2]International Centre for Theoretical Physics (ICTP), P.O. Box 586, I-34014 Trieste, Italy

In the present talk, we investigate how topological quantum pumping on the Rice-Mele model may be affected by interaction with a Caldeira-Leggett thermal bosonic reservoir. Remarkably, we find that a bath at a low enough temperature can partially counteract non-adiabatic effects that lead to deviations from perfect charge quantization. Indeed, in the limit of infinite pumping cycles and for our choice of system-bath interaction, we find that the charge pumped in the dissipative case can be closer to the integer value than the one coming from a perfectly coherent evolution. We will show that this interesting effect can be viewed in the Floquet framework: with respect to the unitary case, the low temperature bath brings to a higher population of the lowest energetic Floquet band, which is the responsible for quantized pumping. Despite being still far from correctly modelling noise in real systems, this study proves that in principle dissipation can improve the performances of devices realizing quantum Thouless pumping.