# TT 26: Quantum Dynamics, Decoherence and Quantum Information (jointly with DY)

Time: Monday 15:00–18:30 Location: BH-N 334

TT 26.1 Mon 15:00 BH-N 334

**Cooling a Magnetic Nanoisland by Spin-Polarized Currents** — •Peter Nalbach[1], Jochen Brüggemann[1], Stephan Weiss[2], and Michael Thorwart[1] — [1]I. Institut für Theoretische Physik, Universität Hamburg, Germany — [2]Theoretische Physik, Universität Duisburg-Essen and CENIDE, Germany

We investigate cooling of a vibrational mode of a magnetic quantum dot by a spin-polarized tunnelling charge current exploiting the magneto-mechanical coupling. The spin-polarized current polarizes the magnetic nano-island, thereby lowering its magnetic energy. At the same time, Ohmic heating increases the vibrational energy. A small magneto-mechanical coupling then permits us to remove energy from the vibrational motion and cooling is possible. We find a reduction of the vibrational energy below 50% of its equilibrium value. The lowest vibration temperature is achieved for a weak electron-vibration coupling and a comparable magneto-mechanical coupling. The cooling rate increases at first with the magneto-mechanical coupling and then saturates.

see: Phys. Rev. Lett. 113, 076602 (2014).

TT 26.2 Mon 15:15 BH-N 334

**Dissipative Landau-Zener transitions with longitudinal and transversal noise** — •Samaneh Javanbakht, Peter Nalbach, and Michael Thorwart — I. Institut f\"{u}r Theoretische Physik Universit\"{a}t Hamburg Jungiusstra\ss{}e 9, 20355 Hamburg

We have studied the Landau-Zener transition probability in a dissipative environment exhibiting both, longitudinal as well as transversal, noise. We employed the numerically exact quasi-adiabatic path integral as well as the approximate nonequilibrium Bloch equations. We find that transversal noise influences the Landau-Zener probability much stronger than longitudinal noise at equal temperature and system-bath coupling. Furthermore we reveal that transversal noise renormalizes the tunnel coupling independent of temperature. Finally, we observe that longitudinal and transversal noise cannot be treated independently but are correlated. This results in an unexpected dependence on the relative sign of the transversal and the longitudinal system-bath coupling.

TT 26.3 Mon 15:30 BH-N 334

**Landau-Zener transitions in a bosonic bipartite quantum system** — •Katharina Kopper, Ralf Blattmann, and Peter Hänggi — Universität Augsburg, D-86135 Augsburg

We study a bipartite quantum system consisting of two coupled optical micro-cavities as an analogue of the bosonic Landau-Zener setup. To account for dissipative effects we employ a Markovian master equation to describe the open system dynamics.

Within this framework we regard the time evolution of the system and its dependency on the characteristic parameters and discuss our findings.

TT 26.4 Mon 15:45 BH-N 334

**Verification for quantum emulation in thermal equilibrium** — •Iris Schwenk, Michael Marthaler, and Gerd Schön — Institut für Theoretische Festkörperphysik - KIT , Karlsruhe

A quantum emulator is an experimental setup that mimics an interesting physical system of some relevance for physics or applications. In order to explore the reliability of a quantum emulator we analyse a system-bath setting in thermal equilibrium. Therefore we compute the reduced density matrix of the system analytically. Applying a diagrammatic approach we get a determining equation for the reduced density matrix. Using this equation we discuss restrictions of the scalability of a quantum emulator and possibilities to avoid them.

TT 26.5 Mon 16:00 BH-N 334

**Fully pulse-controlled gate operations on qubit chains with always on coupling** — Holger Frydrych[1], •Michael Marthaler[2], and Gernot Alber[1] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, D-64289 Darmstadt — [2]Institut für Theoretische Festkörperphysik , Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany

We investigate a linear chain of qubits with strong, always-on nearest-neighbour couplings. Always-on coupling is simple to realize, but it raises the question of how to decouple the qubits. One possibility would be strong detuning, but the energy splitting of many qubits can only be changed slowly or the energy is fixed by tuning to a symmetry point which reduces decoherence.We propose a selective dynamical decoupling scheme, which is capable of dynamically suppressing any coupling in the chain as needed, by applying certain sequences of local pulses to individual qubits. We demonstrate how this pulse control can be used to implement single-qubit rotations and an entangling two-qubit gate between any neighbouring qubits in the chain. We find that high fidelities can be achieved as long as the number of permanently coupled qubits is not too large. As a specific example we discuss the concrete parameters needed to implement our proposal with superconducting flux qubits.

TT 26.6 Mon 16:15 BH-N 334

**Entanglement content of non-equilibrium steady states** — •Zoltán Zimborás[1] and Viktor Eisler[2] — [1]University College London, UK — [2]Eötvös University, Budapest, Hungary

We study the nonequilibrium steady state of a chain of harmonic oscillators and a chain of free fermions, resulting from an initial state where the two sides of the system are prepared at different temperatures. The steady state is constructed explicitly and the logarithmic negativity and mutual information is calculated between two adjacent segments of the chain. We find that, for the fermion chain the mutual information diverges logarithmically, while for the harmonic chain the steady-state negativity follows an area law and is a sum of contributions pertaining to left- and right-moving excitations emitted from the two reservoirs. As a particular case, we also discuss a local quench where both sides of the chain are initialized in their respective ground states.

[1] V. Eisler, Z. Zimborás, Phys. Rev. A 89, 032321 (2014)
[2] V. Eisler, Z. Zimborás, arXiv:1406.5474

TT 26.7 Mon 16:30 BH-N 334

**Numerical Complexity in Non-Markovian Quantum Dynamics** — •Michael Wiedmann and Jürgen T. Stockburger — Institute for Complex Quantum Systems, Ulm University, Albert-Einstein-Allee 11, D-89069 Ulm

Decoherence phenomena beyond perturbation theory are commonplace in condensed-matter physics, biophysics and strongly driven systems. The stochastic Liouville-von Neumann equation (SLN) [1] builds an exact, time-local and non-perturbative framework to tackle non-Markovian open system dynamics in these cases. In this technique the propagation of individual samples is non-unitary, the norm of quantum states is not preserved. Any resource-conscious numerical implementation faces the problem of deteriorating signal-to-noise ratios and increasing numbers of required trajectories. We present a propagation scheme that offers significant advances in sample statistics' efficiency with emphasis on strong dephasing. Apart from transient dynamics we consider system correlation functions of steady states in equilibrium and non-equilibrium settings.

[1] J. T. Stockburger and H. Grabert, PRL 88, 170407 (2002)

**15 min. break**

TT 26.8 Mon 17:00 BH-N 334

**Universal short-time response and formation of correlations after quantum quenches** — •Klaus Morawetz — Münster University of Applied Sciences, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics (IIP), Avenida Odilon Gomes de Lima 1722, 59078-400 Natal, Brazil — Max-Planck- Institute for the Physics of Complex Systems, 01187 Dresden, Germany

The short-time evolution of two distinct systems, the pump and probe experiments with semiconductor and the sudden quench of cold atoms in an optical lattice, is found to be described by the same universal response function. This analytic formula at short time scales is derived from the quantum kinetic theory approach observing that correlations need time to be formed. The influence of finite trapping potential is derived and discussed as well as Singwi-Sjølander local field corrections. The quantum kinetic equation allows to understand how two-particle correlations are formed and the screening and collective modes are build up.

K. Morawetz, Phys. Rev. B 90 (2014) 075303:
K. Morawetz, P. Lipavský, M. Schreiber, Phys. Rev. B 72 (2005) 233203:
K. Morawetz, Phys. Rev. E 66 (2002) 022103:
K. Morawetz, M. Bonitz, V. G. Morozov, G. Röpke, D. Kremp, Phys. Rev. E 63 (2001) 20102:
K. Morawetz, V. Spicka, P. Lipavský: Phys. Lett. A 246 (1998) 311:

TT 26.9 Mon 17:15 BH-N 334

**Computing the Markovian dynamics of periodically driven systems** — •Daniel Pagel, Andreas Alvermann, and Holger Fehske — Institut für Physik, Ernst-Moritz-Arndt-Universität, 17487 Greifswald, Germany

The dissipative dynamics of a quantum system that is weakly coupled to an environment can be studied with Markovian master equations. Solution of the master equation requires the choice of a computational basis. In this work we describe how exact diagonalization and the Floquet approach can be combined in a solution strategy for the master equation that is applicable also for periodically driven systems. For the example of strongly coupled quantum bits, where the usually employed quantum optical master equation has to be replaced by the master equation in the coupled eigenbasis, we compute the dissipative dynamics of initially entangled states and study the properties of the asymptotic state using correlation functions.

TT 26.10 Mon 17:30 BH-N 334

**Non-equilibrium quantum dynamics of Gaussian states in open harmonic chains** — •Thomas Motz, Jürgen T. Stockburger, and Joachim Ankerhold — Institute for complex quantum systems, Ulm University, Albert-Einstein-Allee 11, D-89069 Ulm, Germany

Strong driving in open quantum systems can reveal counterintuitive effects such as the dynamical creation of negative entropy changes [1] and entanglement between two Gaussian modes in a common reservoir [2]. The effect that dissipation and strong driving in combination can lead to specific quantum characteristics like entanglement and offers much potential for quantum information processing and the studies of mesoscopic thermodynamics. A rich tool to study dynamic effects in open systems proved to be the stochastic Liouville-von Neumann equation [3]. We avoid the stochastic sampling in our approach where the dynamics of the covariance matrix in a few-body system is directly described by a deterministic equation of motion. We apply this approach to a bipartite asymmetric system where entanglement generation and its sensitivity to the asymmetry is studied. Since the memory requirements for Gaussian states grow only quadratically with system size, our approach is also targeted at more complex settings like multiple coupled modes in a common or several separated reservoirs. Our equations of motion allow optimal control theory to be applied with ease.

[1] R. Schmidt et al., PRL 107, 130404 (2011).
[2] R. Schmidt et al., PRA 88, 052321 (2013).
[3] J. T. Stockburger and H. Grabert, PRL 88, 170407 (2002).

TT 26.11 Mon 17:45 BH-N 334

**Markovianity and Consistency in closed spin lattices** — •Daniel Schmidtke and Jochen Gemmer — Fachbereich Physik, Universität Osnabrück, Osnabrück, Germany

Dynamics of closed quantum systems may be mapped onto stochastic processes in case they are in accordance with conditions regarding Markovianity and Consistency. These conditions can be derived from the path measures of the Consistent Histories approach by introducing a decoherence functional and conditional transfer-probabilities. Depending on the so called memory range one distinguishes one-step, two-step, ... etc. Markovianity. To demonstrate that these conditions are indeed fulfilled in some closed quantum systems an detailed numerical investigation of spin lattices has been done by directly quantifying the negligible Non-Markovianity and negligible Non-Consistency. Though Markovianity and Consistency show very similar dependencies on, e.g., the time steps between measurements or coupling strengths within the spin system, there are no analytical proofs regarding this correlation.

TT 26.12 Mon 18:00 BH-N 334

**Dynamics of the dissipative Dicke Model for a large number of atoms** — •Christos Bokas, Björn Kubala, and Joachim Ankerhold — Institute for Complex Quantum Systems, Ulm University, Ulm, Germany

The Dicke Hamiltonian is used to model the coupling of a cloud of atoms to a harmonic oscillator mode. In the thermodynamic limit, a phase transition occurs when increasing the coupling strength, shifting the system from a 'normal' to a 'superradiant' state, which exhibits strong correlations between the two subsystems.

Dynamics *close to this equilibrium state* is described by the well-known Holstein-Primakov approach [1] in terms of two effective Hamiltonians containing two coupled harmonic degrees of freedom.

We aim to describe the *full coherent and dissipative dynamics* by deriving a mapping to a single effective potential valid for a large number of atoms. Starting from a highly excited atomic state, oscillations of excitations between atoms and cavity and the eventual decay to equilibrium can, hence, be studied within this approach.

[1] C. Emary and T. Brandes, Phys. Rev. E **67**, 066203 (2003).

TT 26.13 Mon 18:15 BH-N 334

**Dynamics of the dissipative Dicke model: superradiance of cold atoms via a superconducting cavity** — Sebastian Fuchs[1,2], •Björn Kubala[1], Miles Blencowe[3], and Joachim Ankerhold[1] — [1]Insitute for Complex Quantum Systems, Ulm University, Ulm, Germany — [2]Northwestern University, Evanston IL, USA — [3]Dartmouth College, Hanover NH, USA

Superradiance is associated with two physical effects: Firstly, the cooperative emission of radiation of a large number of excited atoms into free space in a quick, strong 'superradiant burst'. Secondly, for sufficiently strong coupling of many atoms to an electromagnetic cavity mode, modeled with the Dicke Hamiltonian, a 'superradiant phase' is found, which shows macroscopic photon occupation and atomic excitation.

The two facets of superradiance can be combined in studying the dissipative dynamics of an initially excited state of the atoms towards equilibrium. We identify and characterize the analogue of the free-space burst in this scenario, and discuss how signatures of normal or superradiant phase are observable for a mesoscopic number of atoms.