TT 73: Quantum Dynamics, Decoherence and Quantum Information (joint session DY/TT)

Time: Wednesday 15:30–18:15 Location: EB 107

TT 73.1 Wed 15:30 EB 107

Modeling Dye-Mediated Photon-Photon Interaction in Condensates of Light — Milan Radonjić[1], •Wassilij Kopylov[2], Antun Balaž[1], and Axel Pelster[3] — [1]Institute of Physics Belgrade, University of Belgrade, Serbia — [2]Department of Physics, TU Berlin, Germany — [3]Department of Physics and Research Center OPTIMAS, TU Kaiserslautern, Germany

Based entirely on the Lindblad master equation approach we obtain a microscopic description of photons in a dye-filled cavity, which features condensation of light [1,2]. To this end we generalize the nonequilibrium approach of Ref. [3] such that the dye-mediated contribution to the photon-photon interaction in the light condensate is accessible. We describe the dynamics of the system by analyzing the resulting equations of motion. In particular, we discuss the existence of two limiting cases for steady states: photon BEC and laser-like. In the former case, we determine the corresponding dimensionless interaction strength relying on realistic experimental data and find a good agreement with the previous theoretical estimate [4]. Furthermore, we investigate how the dimensionless interaction strength depends on the respective system parameters such as the effective temperature of the dye and the number of the dye molecules.

[1] J. Klaers et al., Nature 468, 545 (2010)
[2] R. A. Nyman and M. H. Szymanska, Phys. Rev. A 89, 033844 (2014)
[3] P. Kirton and J. Keeling, Phys. Rev. Lett. 111, 100404 (2013)
[4] E. C. I. van der Wurff et al., Phys. Rev. Lett. 113, 135301 (2014)

TT 73.2 Wed 15:45 EB 107

Optimized polarization control in a Central-Spin System — •Alessandro Ricottone[1], Yi Nan Fang[2], Stefano Chesi[2], and William Coish[1] — [1]Department of Physics, McGill University, Montréal, Québec H3A 2T8, Canada — [2]Beijing Computational Science Research Center, Beijing 100084, China

We study the dissipative dynamics of the central-spin system, where one central spin is homogeneously coupled with many ancilla spins. We find that, due to a combination of the quantum Zeno effect and many-body collective behaviour of the ancilla spins, the dissipation rate can be optimized to minimize the time scale for polarization dynamics. An archetypical example of this model is given by an electron spin coupled to nuclear spins in a quantum dot via hyperfine interactions, but the same Hamiltonian can be applied in many other physical scenarios. These results may be important for protocols to quickly polarize nuclear spins in semiconductor quantum dots or to rapidly and efficiently equilibrate a quantum annealer.

TT 73.3 Wed 16:00 EB 107

Quantum heat transport and rectification through anharmonic chains between reservoirs — •Thomas Motz, Joachim Ankerhold, and Jürgen Stockburger — Ulm University, Institute for Complex Quantum Systems

We present a novel dynamical description of quantum heat transfer through anharmonic chains between thermal reservoirs [1,2]. The approach is non-perturbative in the system-bath coupling and also allows to include disorder and the presence of external driving. Technically, we start from the formally exact stochastic Liouville-von Neumann (SLN) treatment of open quantum dynamics [3] and consider the situation of ohmic dissipation. For purely harmonic chains this leads to a very efficient scheme to study also very long chains and flux-flux correlations. In the anharmonic situation, we particularly study thermal rectification, the impact of disorder, and strong coupling to the heat baths.

[1] J. T. Stockburger and T. Motz, Fortschr. Phys. **65**, 1600067 (2017)
[2] T. Motz et al., New J. Phys. **19** 053013 (2017)
[3] J. T. Stockburger and H. Grabert, PRL **88** 170407 (2002)

TT 73.4 Wed 16:15 EB 107

Stochastic simulation of open-system quantum dynamics: overcoming the curse of non-Hermitian propagation — Konstantin Schmitz[1], Thomas Unden[2], and •Jürgen Stockburger[1] — [1]Ulm University, Institute for Complex Quantum Systems — [2]Ulm University, Intstiute for Quantum Optics

The Stochastic Liouville-von Neumann equation [1] provides an exact numerical simulation strategy for quantum systems coupled to a reservoir with Gaussian fluctuations of arbitrary spectrum (linear dissipation). Individual stochastic samples are propagated with Hamiltonians containing random non-Hermitian terms, leading to poor signal-to noise ratios in some cases. However, the efficiency of this approach has recently improved dramatically through time-domain projection techniques, implemented as reduction operations [2]. In addition, we present two recently developed sampling strategies which show significantly improved scaling with the strength of the dissipative interaction and with the reservoir memory time: a) anticorrelated sampling, exploiting a gauge-like symmetry and b) reducing the non-unitary terms in sample propagation through convex optimization techniques.

[1] J. T. Stockburger and H. Grabert, PRL **88** 170407 (2002)
[2] J. T. Stockburger, EPL **115**, 40010 (2016)

TT 73.5 Wed 16:30 EB 107

Fidelity plateaux from correlated noise in cold-atom quantum simulators — •Scott R Taylor and Chris A Hooley — University of St Andrews, St Andrews, UK

We demonstrate that, in a quantum simulation protocol based on the Hubbard model, correlated noise in the Hubbard parameters leads to arbitrarily long plateaux in the state-preparation fidelity as a function of elapsed time. We argue that this correlated-noise scenario is the generic one in the cold-atom context, since all of the Hubbard-model parameters ultimately depend on the same set of lasers. We explain the formation of such a plateau using the Bloch-sphere representation, deriving analytical expressions for its start and end times and its height.

15 min. break

TT 73.6 Wed 17:00 EB 107

Non-Markovian Quantum Dynamics - On the way to real-time simulations of heat engines — •Michael Wiedmann, Jürgen T. Stockburger, and Joachim Ankerhold — Institute for Complex Quantum Systems, Ulm University, Albert-Einstein- Allee 11, D-89069 Ulm

The experimental miniaturization of heat engines down to the single-atom level questions classical concepts such as work and heat flux. In the regime of higher temperatures, well-established theories from classical thermodynamics apply, where surrounding heat baths exchange energy and particles with a much smaller system of interest. Quantum mechanically, the situation is more intricate though. The non-locality of quantum mechanical wave functions induces system-reservoir correlations and entanglement which may have profound impact on thermodynamic properties, particularly for condensed phase systems at cryogenic temperatures. The fully dynamical approach of the stochastic Liouville-von Neumann equation (SLN) builds an exact, time-local and non-perturbative framework to tackle non-Markovian dynamics at low temperatures, for arbitrarily driven systems and strong coupling [1]. With emphasis on particularities induced by anharmonic potentials, we present an efficient real-time propagation scheme for a single quantum oscillator coupled to dissipative reservoirs. Aspects of work and heat flux are analyzed in the regime of strong system-reservoir couplings and in the context of reservoir fluctuations far from equilibrium.

[1] M. Wiedmann et al., Phys. Rev. A **94**, 052137 (2016).

TT 73.7 Wed 17:15 EB 107

Jump-based feedback control in the Lipkin-Meshkov-Glick model — •Sven Zimmermann — Technische Universität Berlin, Deutschland

We apply a measurement based feedback control scheme to the dissipative Lipkin-Meshkov-Glick model to affect the quantum phase transition [1-3]. Here we use the Wiseman-Milburn control scheme and apply it on the level of the master equation to the system dissipator [4, 5]. Our interest lies in the steady state properties of the Lipkin-Meshkov-Glick system under the feedback action. By numerically calculating the average spin expectation values, we show that the considered control scheme changes the critical point of the phase transition. Furthermore, by investigating the waiting time distribution and the concurrence, we show, that the emission properties of the system and the entanglement can be significantly modified by the considered closed-loop control scheme.

[1] H.J. Lipkin, N. Meshkov and A. Glick, Nucl. Phys., 62, 188 (1965)
[2] S. Morrison and A. S. Parkins PRL 100, 040403 (2008)
[3] W. Kopylov and T. Brandes, NJP 17, 103031 (2015)
[4] H. M. Wiseman and G. J. Milburn, Quantum Measurment Control, Cambrige University Press, Campridge (2010)
[5] G. Kießlich, C. Emary, G. Schaller and T. Brandes, NJP 14, 123036 (2012)

TT 73.8 Wed 17:30 EB 107

Architectures for quantum simulation showing a quantum speedup — •Juan Bermejo-Vega[1], Dominik Hangleiter[1], Martin Schwarz[1], Robert Raussendorf[2], and Jens Eisert[1] — [1]Dahlem Center for Complex Quantum Systems, Freie Universitat Berlin, 14195 Berlin, Germany — [2]University of British Columbia, Department of Physics and Astronomy, Vancouver, BC, V6T 1Z1, Canada

A main goal in the field of quantum simulation is to demonstrate a quantum speedup (or "quantum computational supremacy"), referring to the experimental realization of a quantum device that computationally outperforms classical computers. In this talk, we present simple and feasible schemes of two-dimensional dynamical quantum simulators with the potential to show such a quantum speedup. In each of the schemes, an initial (potentially disordered) product state is prepared, followed by a short-time evolution under a basic translationally invariant Hamiltonian with nearest-neighbor interactions, and a final measurement in a fixed basis. The correctness of the final state preparation in each scheme is fully efficiently certifiable. Our schemes are tailored to platforms of cold atoms in optical lattices, and cannot be efficiently classically simulated under plausible complexity-theoretic assumptions. This work shows that benchmark settings exhibiting a quantum speedup may require little control in contrast to universal quantum computing. Thus, our proposal puts a convincing experimental demonstration of a quantum speedup within reach in the near term.

TT 73.9 Wed 17:45 EB 107

Analytical results for the non-Markovianity of quantum spin ensembles — •Remy Dubertrand[1,2], Alexandre Cesa[2], and John Martin[2] — [1]Institut für Theoretische Physik Universität Regensburg 93040 Regensburg, Germany — [2]Institut de Physique Nucleaire, Atomique et de Spectroscopie, CESAM, University of Liege, Bat. B15, B - 4000 Liege, Belgium

We study the non-Markovian character of spin ensembles. The ensemble is assumed to be isolated and a subset of spins is taken as the system, while the remaining part of the ensemble is taken as the environment. For a large class of interaction range, we derive analytical expressions for the non-Markovianity [1] following a recently introduced measure [2]. In particular, we investigate the thermodynamic limit and derive conditions to observe a Markovian dynamics or not. For a system of a single spin, it is explicitly shown that our results agree with the other known measures of non-Markovianity. We believe that our work can be used to investigate further the dynamics of fundamental models in condensed matter physics from the new perspective of (non-)Markovianity.

[1] R. Dubertrand, A. Cesa, J. Martin, to be submitted
[2] S. Lorenzo, F. Plastina, and M. Paternostro, Phys. Rev. A 88 (2013)

TT 73.10 Wed 18:00 EB 107

Quantum Dynamics beyond Gaussians: from Coarse Graining to a Tower of Scales via Multiresolution — •Antonina N. Fedorova and Michael G. Zeitlin — Russia, 199178, St.Petersburg, V.O. Bolshoj pr., 61, IPME RAS, Mathematical Methods in Mechanics Group

We present a family of methods which can describe complex behaviour in quantum ensembles. We demonstrate the creation of nontrivial (meta) stable states (patterns), localized, chaotic, entangled or decoherent, from the basic localized modes in various collective models arising from the quantum hierarchy described by Wigner-Moyal-von Neumann-like equations. The advantages of such an approach are as follows: i). the natural description of localized states in any proper functional realization of (Hilbert) space of states, ii). the representation of hidden symmetry of a chosen representation of the functional model describes the (whole) spectrum of possible states via the multiresolution decomposition. Effects we are interested in are as follows: 1. a hierarchy of internal/hidden scales (time, space, phase space); 2. non-perturbative multiscales: from slow to fast contributions, from the coarser to the finer level of resolution/decomposition; 3. the coexistence of the levels of hierarchy of multiscale dynamics with transitions between scales; 4. the manifestation of the key features of the complex quantum world such as the existence of chaotic and/or entangled states with possible destruction in "open/dissipative" regimes due to interactions with quantum/classical environment and transition to decoherent states.