Q 69: Open Quantum Systems II (joint session Q/QI)

Time: Friday 11:00–13:00 Location: HS I

Q 69.1 Fri 11:00 HS I

Controlling matter phases beyond Markov — •Baptiste Debecker, John Martin, and François Damanet — University of Liège, Liège, Belgium

Controlling phase transitions in quantum systems via coupling to reservoirs has been mostly studied for idealized memory-less environments under the so-called Markov approximation. Yet, most quantum materials and experiments in the solid state, atomic, molecular and optical physics are coupled to reservoirs with finite memory times. Here, using the spectral theory of non-Markovian dissipative phase transitions developed in the companion paper [Debecker, Martin, and Damanet (to be published)], we show that memory effects can be leveraged to reshape matter phase boundaries, but also reveal the existence of dissipative phase transitions genuinely triggered by non-Markovian effects.

Q 69.2 Fri 11:15 HS I

Markovianity in Quantum Thermodynamics: Principles and Practice — •Thomas Schulte-Herbrüggen[1], Emanuel Malvetti[1], Frederik vom Ende[2], and Gunther Dirr[3] — [1]Technical University of Munich (TUM) — [2]FU Berlin — [3]University of Würzburg

We connect quantum control theory with quantum thermodynamics for open Markovian systems. We sketch a *Markovianity Filter*, i.e. how to construct the Markovian counterparts of several types of quantum Thermal Operations (via Lie semigroups). By way of example, we parameterise the Markovian subset of maps within the set of all Thermal Operations.

As an application, we give inclusions in terms of d-majorisation for reachable sets of bilinear control systems, where coherent controls are complemented by switchable couplings to a thermal bath as additional resource.

Q 69.3 Fri 11:30 HS I

The quantum harmonic oscillator in a dissipative bath of anyon pairs — •Nils-Henrik Meyer[1], Michael Thorwart[1], and Axel Pelster[2] — [1]I. Institute of Theoretical Physics, University of Hamburg, Germany — [2]Physics Department and Research Center OPTIMAS, Rheinland-Pfälzische Technische Universität Kaiserslautern-Landau, Germany

We determine the quantum statistical dynamics of a quantum mechanical harmonic oscillator coupled to a heat bath constructed of 1D anyons. For that, we use the quantum mechanical path integral of anyon pairs in one dimension introduced by Grundberg and Hansson [1]. These anyons are characterized by one statistical parameter entering in the dispersion relation of the heat bath. By this, we formally obtain a heat bath of free bosons which, however, couple nonlinearly to the system. By utilizing the smearing formula of Ref. [2], we find a direct nontrivial influence of the anyons on the spectral density and therefore the dynamics of the system up to second order in a perturbative approach. We show that the relaxation properties of the system are directly determined by the anyonic statistical parameter of the bath.

[1] J. Grundberg and T. H. Hansson. Mod. Phys. Lett. A **10**, 985 (1995).
[2] H. Kleinert, W. Kürzinger, and A. Pelster. J. Phys. A **31**, 8307 (1998).

Q 69.4 Fri 11:45 HS I

Microscopic model for a nonliner dissipative dielectric medium — •Nils Berhausen, Sascha Lang, and Stefan Yoshi Buhmann — Institut für Physik, Universität Kassel, Heinrich-Plett-Straße 40, 34132 Kassel, Germany

Through nonlinear optical effects, such as the Kerr effect, it is experimentally possible to artificially generate spacetimedependent refractive index modulations via strong electric fields. Suitable experimental setups allow for generating backgrounds which affect the field dynamics similarly to nontrivial curved spacetimes. For instance, tabletop setups with refractive index modulations can give rise to photon pair creation that can be observed by the technique of electro-optic sampling in certain nonlinear crystals. In existing theoretical works, the dynamics of nonlinear optical media is usually described in a phenomenologically motivated extension of linear macroscopic electrodynamics, which does not necessarily cover the full quantum vacuum dynamics. In this talk, I will present first results on an alternative microscopic approach for nonlinear optical media. To incorporate nonlinearities, we describe the medium with anharmonic oscillators and allow those oscillators to nonlinearly couple to the electric field. The resulting model takes into account a number of nonlinear optical effects, including second-harmonic generation.

Q 69.5 Fri 12:00 HS I

Calculating two-time correlations for dissipative, interacting spin systems with phase space methods — •Jens Hartmann and Michael Fleischhauer — RPTU Kaiserslautern, Kaiserslautern, Germany

The recently developed Truncated Wigner Approximation (TWA) for spins [1,2] is a powerful technique to simulate dissipative, interacting spin systems with a large number of spins taking into account leading-order quantum effects. However, determining two-time correlations within phase space approaches is notoriously difficult. We here developed an efficient method to numerically calculate multi-time-correlations of strongly coupled spins and demonstrate its accuracy for different benchmark problems. Furthermore of special interest is the superradiant emission from atoms coupled to a waveguide, which can be described very well with our method [3]. We compute the second order correlation function of the emitted light for different times and see a good agreement between the theoretical and experimental data for the superradiant bursts and the corresponding behavior of the correlation function.

[1,2] C. Mink et al., 10.21468/SciPostPhys.15.6.233, PhysRevResearch.4.043136
[3] F. Tebbenjohanns et al., PhysRevA.110.043713

Q 69.6 Fri 12:15 HS I

Exploring non-Markovian dynamics in microwave spin control of group-IV color centers coupled to a phononic bath — •Mohamed Belhassen[1], Gregor Pieplow[1], and Tim Schröder[1,2] — [1]Humboldt-Universität zu Berlin, Berlin, Germany — [2]Ferdinand-Braun-Institut, Berlin, Germany

Microwave control is a well-established technique for driving the electronic spin of diamond color centers. In our earlier work [1], we demonstrated that optimizing the orientation of the static magnetic field lifting the spin degeneracy and the polarization of the microwave field driving the spin, is essential for achieving efficient control conditions in a low strain environment. Expanding on this, we now incorporate the phononic bath, which introduces decay and decoherence to the qubit's quantum state. We examine the system dynamics using both Markovian and non-Markovian master equations, revisiting the interplay between magnetic and microwave field orientations and applied strain, with a focus on their impact on the qubit decay and decoherence times. We interpret our simulation results and compare them with the most recent experimental results. Finally, we assess the validity of the Born-Markov approximation and investigate how bath memory effects impact quantum state evolution.

[1] G. Pieplow, M. Belhassen, T. Schröder, Phys. Rev. B 109, 115409

Q 69.7 Fri 12:30 HS I

Non-Markovian dynamics of giant atificial atoms at finite temperature — •Mei Yu[1], Hai Chau Nguyen[1], Walter Strunz[2], Valentin Link[2], and Stefan Nimmrichter[1] — [1]University of Siegen, Siegen, Germany — [2]Dresden University of Technology, Dresden, Germany

Superconducting qubits, when coupled to either a meandering transmission line or to surface acoustic waves, enable the creation of giant artificial atoms. These atoms interact with the waveguide through two or more spatially separated contact points, providing a tunable platform to explore non-Markovian dynamics with significant memory effects beyond the atomic lifetime. Thus far, the non-Markovian characteristics of this system have been analyzed at zero temperature and validated experimentally [1]. In this work, we examine the influence of finite temperature on the non-Markovian behavior of giant atom dynamics. Contrary to intuitive expectations, we find that thermal effects can suppress the spontaneous emission decay rate rather than enhancing it.

[1] G. Andersson, B. Suri, L. Guo, T. Aref, and P. Delsing, Non-exponential decay of a giant artificial atom, Nature Physics 15, 1123 (2019).

Q 69.8 Fri 12:45 HS I

On the foundation of quantum physics — •Hans-Otto Carmesin — Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen

Quantum physics, QP, is a mystery, described by unexplained postulates (Hilbert et al., 1928). However, evident properties of volume in nature, corresponding to space and vacuum, provide the volume dynamics, VD (Carmesin 2023, 2024) - and the VD implies the postulates of QP. Moreover, the VD provides and explains the wave function as well as the Schrödinger equation, including generalizations. Naturally, the VD provides the value of the dark energy, properties of space and of vacuum, as well as the solution of the Hubble tension.

Furthermore, the VD implies many fundamental physical results.

Literature

Hilbert, D.; Nordheim, L.; Neumann, J v. (1928): Über die Grundlagen der Quantenmechanik. Mathematische Annalen, pp. 395-407.

Carmesin, H.-O. (2023): Geometrical and Exact Unification of Spacetime, Gravity and Quanta. Berlin: Verlag Dr. Köster.

Carmesin, H.-O. (2024): How Volume Portions Form and Found Light, Gravity and Quanta. Berlin: Verlag Dr. Köster.

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