Q 46: Open Quantum Systems II

Time: Thursday 11:00–13:00 Location: P 4

Invited Talk Q 46.1 Thu 11:00 P 4

Squeezed Light and Optimal Phase Estimation for Quantum Metrology — •Mojdeh Shikhali Najafabadi[1], Luis L. Sánchez-Soto[2], Joel F. Corney[3], and Gerd Leuchs[1,4] — [1]Max Planck Institute for the Science of Light — [2]Departamento de Óptica, Facultad de Física, Universidad Complutense, 28040 Madrid, Spain — [3]School of Mathematics and Physics, University of Queensland, Brisbane, Queensland 4072, Australia — [4]Institut für Optik, Information und Photonik, Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen, Germany

Quantum metrology has progressed rapidly over the past decade, yet many approaches still rely on idealised models or tightly controlled laboratory conditions that limit their practical relevance. At its core, quantum metrology relies on four key stages -probe preparation, parameter encoding, measurement, and estimation- each of which must be optimised to achieve precision beyond classical limits. In this talk, I focus on some central components of this framework. First, I introduce squeezed states and phase-space approaches, with emphasis on the generation of quantum resources using resonance-based light-matter interactions and Kerr nonlinearities. I present our theoretical study of squeezing mechanisms arising from resonant nonlinear interactions between a coherent optical pulse and an atomic vapour confined within photonic crystal fibres. Finally, I discuss an asymptotically optimal phase-estimation protocol based on Adaptive Quantum State Estimation (AQSE) for squeezed vacuum states and present recent results from our work.

Q 46.2 Thu 11:30 P 4

From lasers to photon Bose–Einstein condensates: A unified description via an open-dissipative Bose–Einstein distribution — •Joshua Krauss, Enrico Stein, and Axel Pelster — Physics Department and Research Center OPTIMAS, RPTU Kaiserslautern-Landau, Kaiserslautern, Germany

Photon condensation was first observed in 2010 within a dye-filled microcavity at room temperature [1] and gained interest since then. In this study we examine how the driven-dissipative nature of a photon Bose–Einstein condensate modifies the condensation process [2]. To this end, we consider a rate-equation model, which can be derived microscopically [3–5]. It depends on external parameters such as emission and absorption rates as well as cavity photon losses [6]. In steady state, the photon occupation follows an open-dissipative Bose–Einstein distribution whose chemical potential is set self-consistently by the dye's ground- and excited-state populations. We show that driven-dissipative parameters strongly alter the distribution and use these results to distinguish photonic condensation from both atomic condensation and lasing [2].

[1] J. Klaers *et alii*, *Nature* **468**, 545 (2010)
[2] J. Krauß *et alii*, *ArXiv:*2510.05917 (2025)
[3] P. Kirton and J. Keeling, *Phys. Rev. Lett.* **111**, 100404 (2013)
[4] M. Radonjić *et alii*, *New J. Phys.* **20**, 055014 (2018)
[5] E. Stein, *PhD. Thesis*, TU Kaiserslautern, (2022)
[6] J. Schmitt *et alii*, *Zenodo*, DOI: 10.5281/zenodo.10852935 (2024)

Q 46.3 Thu 11:45 P 4

Towards an autonomous optomechanical Maxwell Demon engine — •Sander Stammbach und Stefan Nimmricher — Universität Siegen

We present a fully autonomous model for a mechanical Maxwell demon engine that converts heat absorbed by a qubit into population inversion of an attached quantum battery system. A damped mechanical oscillator acts as a pointer that incorporates the essential demon function of information acquisition about the qubit state and subsequent feedback into the system dynamics, replacing external measurements and control operations. This is achieved by means of the Holstein Hamiltonian, which makes the pointer*s equilibrium position depend on the qubit state and thereby leads to a state-dependent effective resonance shift. The mechanism enables a selective energy transfer to an attached spin system that acts as the quantum battery. We derive both local and global Lindblad master equations for the coupled system and identify the parameter regimes in which the engine operates efficiently. The figure of merit is the resulting steady-state population inversion of the battery, quantified in terms of ergotropy. Based on these results, we discuss the necessary conditions for practical implementations of the demon engine on realistic experimental platforms.

Q 46.4 Thu 12:00 P 4

Dissipative generation of currents by nonreciprocal local and global environments — •Catalin-Mihai Halati — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Str. 38, 01187 Dresden, Germany

We investigate the mechanisms necessary for the stabilization of complex quantum correlations by exploring dissipative couplings to nonreciprocal reservoirs. We analyze the role of locality in the coupling between the environment and the quantum system of interest, as we consider either local couplings throughout the system, or a single global coupling. We contrast the results obtained for the two scenarios in which a chain of strongly interacting hardcore bosonic atoms is coupled directly to Markovian kinetic dissipative processes, or experiences effective dissipation through the mediation of the field of a lossy optical cavity. To investigate the dissipative dynamics of the many-body quantum systems considered we perform numerical simulations employing matrix product states methods. We show that by coupling atomic tunneling terms to the global field of a dissipative cavity we can stabilize at long times both finite currents and current-current correlations throughout the atomic chain. This is in contrast to the setup in which dissipation acts directly via local tunneling processes, where currents arise in a narrow region of the system and the current-current correlations are rapidly decaying.

Q 46.5 Thu 12:15 P 4

Dissipative loading of ultracold atom tweezer arrays — •Lara Giebeler[1], Alexander Schnell[1], Monika Aidelsburger[2,3,4], and André Eckardt[1] — [1]Institute for Physics and Astronomy, Technical University Berlin — [2]Munich Center for Quantum Science and Technology — [3]Max-Planck-Institut für Quantenoptik — [4]Fakultät für Physik, LMU Munich

Using ultracold atoms in quantum computing and simulation often requires arbitrary single-atom control, typically achieved with optical tweezer arrays. However, defect-free loading of large-scale arrays remains challenging due to the slow speeds and limited loading fidelities of stochastic preparation methods.

To overcome these limitations, in this work we introduce a dissipative scheme for loading atoms into tweezers, mediated by laser-coupled interactions with a fermionic bath. In particular, we explore the trade-off between loading time and fidelity depending on the strength of the system bath coupling and the impact of reservoir size and temperature.

Q 46.6 Thu 12:30 P 4

Time complexity of dissipative quantum search with resetting — •Sayan Roy[1,2], Emma King[1,2], Francesco Mattiotti[2], Markus Bläser[3,4], and Giovanna Morigi[2,4] — [1]Equal contribution — [2]Theoretical Physics, Saarland University, 66123 Saarbrücken, Germany — [3]FR Informatics, Saarland University, 66123 Saarbrücken, Germany — [4]Center for Quantum Technologies (QuTe), Saarland University, Campus, 66123 Saarbrücken, Germany

Searching a database is a central task in computer science and is paradigmatic of transport and optimization problems in physics. For an unstructured search, Grover's algorithm predicts a quadratic scaling of the search time with the database size N, $t_s \sim \sqrt{N}$. Numerical studies suggest that the time complexity t_s can change in the presence of feedback, injecting information during the search. We determine the time complexity of the quantum analog of a randomized algorithm, which implements feedback in its simplest form. The search is a continuous-time quantum walk on a complete graph, where the target is continuously monitored by a detector. Additionally, the quantum state is reset to the initial state if the detector does not click within a specified time interval. This yields a non-unitary, non-Markovian dynamics. We optimize the search time as a function of the hopping amplitude, detection rate, and resetting rate. We identify parameter regimes in which the search time scales as $t_s \sim N^\alpha$ with $\alpha < 1/2$, achieving a time complexity that may surpass the Grover optimal bound.

Q 46.7 Thu 12:45 P 4

Adiabatic steering and entanglement generation using dissipative quantum systems — •Keshav Venkataraman[1,2,3], Adrian Parra-Rodriguez[1,2,3], Marko Ljubotina[2,3], and Peter Rabl[1,2,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [2]Physics Department, Technical University of Munich, TUM School of Natural Sciences, Lichtenbergstr. 4, 85748 Garching, Germany — [3]Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 München, Germany

Adiabaticity represents one of the most versatile tools to engineer quantum states of a coherent system, but these schemes typically require large run-times to achieve high fidelities. Various "Shortcuts to Adiabaticity" have been proposed to counteract these losses, to carry out adiabatic sweeps faster than uncontrolled dissipation processes. When the family of target states is known, a new scheme called "Leakage minimization"(PRX Quantum 3, 030343 (2022)) can be used to optimize either the path taken by the tunable parameter or the time-varying amplitudes of auxilliary control fields required to minimize non-adiabatic losses.

This talk focuses on extending this scheme to the dissipative regime, using the steady state entanglement generation protocol of Phys. Rev. A 91, 042116. Such schemes generically involve trade-offs between the entanglement content of the final dark state and its relaxation time (PRX Quantum 5, 040305). Adiabatic manipulations, in contrast, can generate highly entangled states much quicker.