QI 17: Decoherence and Open Systems II

Time: Thursday 15:00–17:30 Location: BEY/0137

QI 17.1 Thu 15:00 BEY/0137

A mathematical justification to apply the secular approximation to the Redfield equation — •Niklas Jung[1,2], Francesco Rosati[1,2], Gabriel Rath[1,2], Frank Wilhelm[1,2], and Peter Schuhmacher[3] — [1]Theoretical Physics, Saarland University, Campus, 66123 Saarbruecken, Germany — [2]Institute for Quantum Computing Analytics (PGI-12), Forschungszentrum Juelich, 52425 Juelich, Germany — [3]Department of High Performance Computing, Institute of Software Technology, German Aerospace Center (DLR), Rathausallee 12, 53757 Sankt Augustin, Germany

In this work, we prove that the solutions of the master equation obtained by applying the secular approximation are also obtained by an approximation of the same order as the one performed to obtain the Redfield equation. We hereby provide a mathematical justification for the secular approximation. We show that the result of applying the secular approximation is obtained naturally by applying a self-consistency argument. This shows that the resulting master equation is also in the same equivalence class of approximations as the Redfield master equation.

QI 17.2 Thu 15:15 BEY/0137

Quantum Zeno effect versus adiabatic quantum computing and quantum annealing — Naser Ahmadiniaz[1], Dennis Kraft[1], Gernot Schaller[1], and •Ralf Schuetzhold[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany — [2]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany

For the adiabatic version of Grover's quantum search algorithm as proposed by Roland and Cerf, we study the impact of decoherence caused by a rather general coupling to some environment. For quite generic conditions, we find that the quantum Zeno effect poses strong limitations on the performance (quantum speed-up) since the environment effectively measures the state of the system permanently and thereby inhibits or slows down quantum transitions. Generalizing our results, we find that analogous restrictions should apply universally to adiabatic quantum algorithms and quantum annealing schemes which are based on isolated Landau-Zener type transitions at avoided level crossings (similar to first-order phase transitions). As a possible resort, more gradual changes of the quantum state (as in second-order phase transitions) or suitable error-correcting schemes such as the spin-echo method may alleviate this problem. `https://doi.org/10.48550/arXiv.2509.04057`

QI 17.3 Thu 15:30 BEY/0137

Cat state preparation and stabilization in open quantum systems — •Suocheng Zhao[1], Sofia Qvarfort[2,3], and Anja Metelmann[1,4,5] — [1]IQMT, KIT, 76344 Eggenstein-Leopoldshafen, Germany — [2]Nordita, KTH Royal Institute of Technology and Stockholm University, SE-106 91 Stockholm, Sweden — [3]Department of Physics, Stockholm University, AlbaNova University Center, SE-106 91 Stockholm, Sweden — [4]TKM, KIT, 76131 Karlsruhe, Germany — [5]ISIS, University of Strasbourg and CNRS

Cat states are a valuable resource for quantum metrology applications, promising to enable sensitivity down to the Heisenberg limit. Moreover, Schrödinger cat states, based on a coherent superposition of coherent states, show robustness against the bit-flip error making them a promising candidate for bosonic quantum codes. Despite these advantages, cat states are generally difficult to generate, and their practical usefulness is fundamentally challenged by environmental noise, which degrades both their preparation and subsequent performance. In this talk, I present three complementary strategies for mitigating the impact of noise, illustrated through the preparation and protection of cat states: (1) accelerating state preparation to outrun noise accumulation using self- and cross-Kerr interactions, as well as quantum optimal control, (2) squeezing the cat states to enhance their intrinsic robustness against noise, and (3) engineering tailored dissipative processes that drive the system toward cat states, and counteract noise to extend their lifetime. Together, these approaches pave the way for deploying cat states in practical quantum technologies.

QI 17.4 Thu 15:45 BEY/0137

Exact Floquet dynamics of strongly damped driven quantum systems — •Konrad Mickiewicz[1], Valentin Link[2], and Walter T. Strunz[1] — [1]Institut für Theoretische Physik, Technische Universität Dresden, D-01062, Dresden, Germany — [2]Institut für Physik und Astronomie, Technische Universität Berlin, D-10623, Berlin, Germany

We introduce an approach for efficiently simulating strongly damped, periodically driven quantum systems [1] using a translationally invariant matrix product operator representation of the influence functional [2]. This allows us to construct a numerically exact Floquet propagator that captures non-Markovian open system dynamics, serving as a dissipative analogue to the Floquet Hamiltonian of isolated periodically driven systems. We apply our method to investigate deviations from equilibrium in spin-boson models by studying the asymptotic reservoir heating. Additionally, we demonstrate that local driving of two qubits can stabilize a transient, environmentally induced buildup of entanglement. Our approach enables a direct analysis of both stationary and transient dynamics in strongly damped, driven quantum systems within a consistent theoretical and computational framework. [1] K. Mickiewicz, V. Link, and W. T. Strunz, arXiv:2511.08754 (2025) [2] V. Link, H.-H. Tu, and W. T. Strunz, Phys. Rev. Lett. 132, 200403 (2024)

QI 17.5 Thu 16:00 BEY/0137

Exceptional Points and Optimized Encoding under Continuous Measurement — •Yves Rottstaedt[1], Andrei Pavlov[2], Alexander Shnirman[2], Yuval Gefen[3], and Bernd Rosenow[1] — [1]Universität Leipzig, Leipzig, Germany — [2]Karlsruhe Institut für Technologie, Karlsruhe, Germany — [3]Weizmann Institute of Science, Rechovot, Israel

We study a system of three qubits subject to blind continuous stabilizer measurements and stochastic bit-flip errors. The resulting open-system dynamics are governed by a non-Hermitian Liouvillian superoperator, which exhibits an exceptional point (EP) at a specific critical error rate: two eigenvalues coalesce and their eigenmodes merge into a single vector, forming a nontrivial Jordan chain. Motivated by this structure, we construct a logical-qubit basis directly from the Liouvillian eigenmodes, thereby incorporating both measurement-induced dissipation and error processes into the encoded subspace. By analyzing the Jordan chain at the EP, we identify dynamical features that enhance logical-state stability over short and intermediate times. We then optimize the logical basis to reproduce these EP-induced properties for arbitrary error rates, effectively extending the favorable dynamical behavior beyond the singular point.

QI 17.6 Thu 16:15 BEY/0137

Closed-Form approximation of Kraus operators for GKSL dynamics in the weak-noise regime — •Shahrukh Chishti[1,2], Francisco Cardenas-Lopez[1], and Felix Motzoi[1,2] — [1]Forschungszentrum Juelich GmbH, Peter Gruenberg Institute, Quantum Control (PGI-8), 52425 Juelich, Germany — [2]Institute for Theoretical Physics, University of Cologne, D-50937 Cologne, Germany

Quantum system interacts unavoidably with the surrounding environment leading to decoherence and thermalization. The dynamics of an open quantum system is equivalently represented with the GKSL equation or the Kraus operators that includes the effects of the environment. For a general noise channel, it is difficult to obtain the Kraus operators from the Lindbladian and vice-versa. We derive a closed-form approximation of the Kraus operators for the GKSL dynamics by employing two approximations; first, weak noise limit of the dynamical map and then discretizing this map via a Riemann summation. Further, this technique could be extended to higher orders in evolution and time-dependent Hamiltonians. These results provide insight into the interaction between noise and coherent dynamics.

30min. break

QI 17.7 Thu 17:00 BEY/0137

Non-perturbative switching rates in bistable open quantum systems: from driven Kerr oscillators to dissipative cat qubits — •Leon Carde[1], Ronan Gautier[1], Nicolas Didier[1], Alexandru Petrescu[2], Joachim Cohen[1], and Alexander McDonald[3] — [1]Alice&Bob, Paris, France — [2]Mines ParisTech, Paris, France —

[3]University of Sherbrooke, Sherbrooke, Canada

In this work, we use path integral techniques to predict the switching rate in a single-mode bistable open quantum system. While analytical expressions are well-known to be accessible for systems subject to Gaussian noise obeying classical detailed balance, we generalize this approach to a class of quantum systems, those which satisfy the recently-introduced notion of hidden time-reversal symmetry. .In particular, in the context of quantum computing, we obtain analytical estimates of bit-flip error rates in cat-qubit architectures. We confirm these findings by comparing our results to numerically exact diagonalization of the Linbladian. Our results provide a path towards exploring switching phenomena in multistable open quantum systems

QI 17.8 Thu 17:15 BEY/0137

Conserved quantities enable the quantum Mpemba effect in weakly open systems — •Iris Ulcakar[1,2], Gianluca Lagnese[1], Rustem Sharipov[2], and Zala Lenarcic[1] — [1]"Jozef Stefan" Institute, Ljubljana, Slovenia — [2]Faculty of Mathematics and Physics, University of Ljubljana, Slovenia

Observation of the quantum Mpemba effect has spurred much interest in its enabling conditions and its relation to the classical counterpart. Here, we consider weakly open many-body quantum systems initialized in different thermal states and examine when the initially farther state relaxes to the (non-equilibrium) steady state faster. We claim that the number of conserved quantities in the unitary part plays a crucial role: the Mpemba effect is possible only when the Hamiltonian commutes with other extensive operators or is integrable. The reason lies in the dynamical evolution happening in spaces of different dimensions. When energy is the only approximately conserved quantity, dissipation pushes the dynamics within a single-parameter manifold of different thermal states. In contrast, for Hamiltonians with several conserved quantities, the dynamics drift in the multi-dimensional space of generalized Gibbs ensembles, whose distance to the steady state is less trivial. We provide numerical results for large system sizes using tensor networks and free-fermion techniques, thereby supporting our claim.