Q 29: Quantum Effects (Entanglement and Decoherence)

Time: Wednesday 11:00–13:00 Location: f442

Q 29.1 Wed 11:00 f442

Simulating open quantum systems using quantum Zeno dynamics — •Sabrina Patsch[1,2], Sabrina Maniscalco[3], and Christiane P. Koch[1,2] — [1]Theoretische Physik, Universität Kassel, Germany — [2]Theoretische Physik, Freie Universität Berlin, Germany — [3]Turku Centre for Quantum Physics, University of Turku, Finland

Quantum simulation is most prominently used to study many-body systems which overtax even the most powerful computers, but quantum simulation is a useful tool to understand complex quantum systems of various types. Here, we present a quantum simulator which is apt to study the role of memory effects in the dynamics of open quantum systems [1]. Instead of investigating the influence of a given environment on a quantum system, we use measurements to induce dissipation in the first place. In the limit of a continuous or very strong measurement, the system's dynamics get confined to a subspace of selectable size – we observe quantum Zeno dynamics. Moreover, we can tune the non-Markovianity, i.e. the information backflow from the environment to the system, and engineer essentially arbitrary Markovian dynamics. Due to the simplicity of our scheme it can be implemented in many experimental platforms, one example being cavity QED [2]. Our quantum simulator opens the path to experimentally study memory effects, dissipation and their interplay in a controlled way – a matter of major importance since open quantum systems are ubiquitous and thus a crucial player in the pursuit of quantum technologies.

[1] Patsch, Maniscalco, Koch, arXiv:1906.11492 (2019)
[2] Raimond, et. al., PRA 86, 032120 (2012)

Q 29.2 Wed 11:15 f442

Excitonic Wave Function Reconstruction from Near-Field Spectra Using Machine Learning Techniques — •Fulu Zheng[1], Xing Gao[1,2], and Alexander Eisfeld[1] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Strasse 38, D-01187 Dresden, Germany — [2]Department of Chemistry, University of Michigan, Ann Arbor, Michigan 48109-1055, USA

A general problem in quantum mechanics is the reconstruction of eigenstate wave functions from measured data. Self-assembled molecular aggregates on dielectric surfaces are promising candidates for optoelectronic devices. Strong interactions between the transition dipoles of the molecules lead to delocalized excitonic eigenstates where an electronic excitation is coherently shared by many molecules [1]. Information about these states is vitally important to understand their optical and transport properties. Here we show that from spatially resolved near field spectra it is possible to reconstruct the underlying delocalized aggregate eigenfunctions [2, 3]. Although this high-dimensional nonlinear problem defies standard numerical or analytical approaches, we have found that it can be solved using a convolutional neural network. For both one-dimensional and two-dimensional aggregates we find that the reconstruction is robust to various types of disorder and noise.

[1] A. Eisfeld, C. Marquardt, A. Paulheim, and M. Sokolowski, Phys. Rev. Lett. 119, 097402 (2017). [2] X. Gao and A. Eisfeld, J. Phys. Chem. Lett. 9, 6003 (2018). [3] F. Zheng, X. Gao and A. Eisfeld, Phys. Rev. Lett. 123, 163202 (2019).

Q 29.3 Wed 11:30 f442

Lie algebra methods for solving the quantum evolution of lossy bosonic chains — •Lucas Teuber and Stefan Scheel — Institut für Physik, Universität Rostock, Albert-Einstein–Str. 23-24, 18059 Rostock, Germany

We solve the quantum evolution of coupled harmonic oscillators experiencing Markovian loss by means of Lie algebraic methods. The coupled oscillators are described in a Liouville space formalism and their dynamics is given by a quantum master equation in Lindblad form. In Liouville space this master equation is generated by a Liouvillian just as the familiar Schrödinger equation is generated by a Hamiltonian. Utilising the Lie algebraic structure induced by the Liouvillian we can find its eigendecomposition which allows to formulate an analytic solution for the quantum state evolution. The analysis of the eigenvalues and eigenvectors enables us to find optimally transported states that mitigate the negative effects of the losses. Furthermore, knowledge of the algebraic structure grants insight into the construction of systems emulating effective non-Hermitian Hamiltonians.

Q 29.4 Wed 11:45 f442

Describing Resonance Energy Transfer by an Open Quantum Systems Approach — •Severin Bang[1], Robert Bennett[1], and Stefan Yoshi Buhmann[1,2] — [1]Institute of Physics, University of Freiburg, Germany — [2]Freiburg Institute for Advanced Studies (FRIAS), Germany

Resonance energy transfer is usually considered as a two particle process. Here we consider multiple donors and/or acceptors which share excitations (e.g. generalised Förster theory). In order to consider the most general initial states possible, we present a description of this process using the language of open quantum systems. This approach results in a master equation of the density matrix describing the multiple donor-acceptor system.

We combine this with a macroscopic quantum electrodynamical description allowing us to extend the usual description of resonance energy transfer to N atoms in arbitrary environments as well as arbitrary degrees of entanglement.

Q 29.5 Wed 12:00 f442

Entanglement and complexity in dissipative quantum cellular automata — •Javad Kazemi and Hendrik Weimer — Institut für Theoretische Physik, leibniz universität hannover, Hannover, Germany

We propose a quantum variant of cellular automata (CA) where dissipative quantum jumps enable irreversibility. As a first step, we extend one dimensional elementary CA to a two-rail platform with periodic time-dependent jump operators. Particularly, we focus on the elementary rule 110, which generates complex space-time patterns possibly capable of universal computation. We investigate a long-time coexistence of quantum entanglement and complexity by interpolating between rule 110 and dissipative dynamics preparing a highly entangled Rokhsar-Kivelson state. As a measure of complexity, we use an approach based on the computational compressibility of the measurement results obtained in the CA.

Q 29.6 Wed 12:15 f442

On open quantum systems in thermal non-ergodic environments — •Carlos Parra-Murillo[1], Max Bramberger[1], Claudius Hubig[2], and Ines de Vega[1] — [1]Department of Physics and Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-University Munich, Germany — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermannstr. 1, 85748, Garching, Germany

In this work we investigate the failure of the weak coupling approximation standard in open quantum systems when non-Gaussian environments. We show that within this scenario, mainly characterized by non-decaying correlation functions, the derivation of a Lindblad equation is no longer possible, thus preventing the thermalization of the open quantum system while producing highly non-Markovian dynamics. We illustrate our statements by considering a thermal spin-boson environment, and show that non-decaying correlations are connected to a 1/f noise that extends to zero frequencies, providing a framework that agrees with experimental observation.

[1] C. A. Parra-Murillo et al, preprint arXiv:1910.10496

Q 29.7 Wed 12:30 f442

Speeding up a single ion thermal machine — •Moritz Goeb[1], Erik Torrontegui[2], Samuel Dawkins[1], and Kilian Singer[1] — [1]Experimentalphysik I, University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel, Germany — [2]Instituto de Fisica Fundamental IFF-CSIC, Calle Serrano 113b, E-28006 Madrid, Spain

We propose speeding up a single ion heat pump based on a tapered ion trap [1]. If a trapped ion is excited in an oscillatory motion axially the radial degrees of freedom are cyclically expanded and compressed such that heat can be pumped between two reservoirs coupled to the ion at the turning points of oscillation. Through the use of invariant-based inverse engineering, we can speed up the process without sacrificing the efficiency of each heat pump cycle. This additional control can be supplied with additional control electrodes or it can be encoded into the geometry of the radial trapping electrodes. We present a novel insight into how speed up can be achieved through the use of inverted harmonic potentials and verify the stability of such trapping conditions [2].

[1]J. Roßnagel, S. T. Dawkins, K. N. Tolazzi, O. Abah, E. Lutz,

F. Schmidt-Kaler and K. Singer, Science 352 325 (2016). [2]E. Torrontegui, S. T. Dawkins, M. Göb and K. Singer, New J. Phys. 20, 105001 (2018).

Q 29.8 Wed 12:45 f442

Optimal Control Methods applied in Magnetic Resonance Fingerprinting — •Amanda Nicotina and Steffen Glaser — Technische Universität München

A method of parameter identification via Magnetic Resonance (MR) is called MR Fingerprinting (FP) recognition. The basic methods of fingerprint recognition are: fingerprinting recording, creation of data base and recognition process with a search algorithm. This can be applied to systems that can be mapped by unique measurable properties. For example, brain tissue identification using MRI. This system can be static or dynamic (influenced by external fields). In the latter, the elements of the data base consist of the time evolved observable under the action of some external field. Since the dictionary, formed by the data base, depends strongly on the external fields, designing them is crucial for the FP process. Therefore, optimal control techniques can be combined with standard FP process for better precision. The Optimal Fingerprinting Process (OFP) allows us to maximize the efficiency of the identification and minimize parameter error. This method will be used to verify relaxation parameters of a spin 1/2 spin particle. The goal is to apply OFP to improve the contrast. Therefore, having better recognition between different brain tissues, for example, the different relaxation values for white matter and gray matter in healthy brain and in Multiple Sclerosis (MS) patients.