TT 92: Quantum Dynamics, Decoherence and Quantum Information (joint session DY/TT)

Time: Friday 10:45–13:00 Location: A 151

TT 92.1 Fri 10:45 A 151

Photon-Resolved Floquet Theory and its Application to Quantum Communication — •Georg Engelhardt[1], Sayan Choudhury[2,3], W. Vincent Liu[2,1], JunYan Luo[4], Victor M. Bastidas[5,6], and Gloria Platero[7] — [1]Southern University of Science and Technology, Shenzhen, China — [2]University of Pittsburgh, Pittsburgh, USA — [3]Harish Chandra Research Institute, UttarPradesh, India — [4]Zhejiang University of Science and Technology, Hangzhou, China — [5]NTT Research, Sunnyvale, USA — [6]Massachusetts Institute of Technology, Cambridge, USA — [7]Instituto de Ciencia de Materiales de Madrid ICMM-CSIC, Madrid, Spain

The semiclassical analysis of Floquet systems can not account for quantum-optical phenomena that rely on the quantized nature of light. Here, we go beyond the semiclassical description by unifying Floquet theory with quantum optics using the framework of Full-Counting Statistics. This formalism, which we dub 'Photon-resolved Floquet theory' (PRFT), is based on two-point tomographic measurements, instead of the two-point projective measurements used in standard Full-Counting Statistics [1,2]. The PRFT predicts the generation of macroscopic light-matter entanglement when atoms interact with multimode electromagnetic fields, thereby leading to complete decoherence in the Floquet-state basis. Employing the PRFT, we propose a quantum communication protocol that may outperform the state-of-art few-photon protocols by two orders of magnitude or better.

[1] G. Engelhardt et al., arXiv:2207.08558 [2] G. Engelhardt et al., arXiv:2311.01509

TT 92.2 Fri 11:00 A 151

Information currents in disordered region — •Nicolas Bauer and Björn Trauzettel — Julius Maximilians Universität Würzburg, Würzburg, Germany

The information lattice is a tool to organize quantum information into different scales and allows the definition of local information and information currents. Hence, it allows to study the flow of information in various systems. We apply the information lattice to a hybrid quench-probe setup, where one part of the system undergoes a quench while another part remains inert. The quench creates a propagating entanglement wave packet, visible in the information lattice, and we study how a disordered region in the probe affects this information current, i.e. scattering and localization of information within the disordered region. In addition, the hybrid setup has an energy selective coupling feature, which allows us to analyze and compare the scattering/localization properties of e.g. fermions at varying energy levels or topological excitations like Majorana zero modes.

TT 92.3 Fri 11:15 A 151

Single-Qubit Error Mitigation by Simulating Non-Markovian Dynamics — •Mirko Rossini, Dominik Maile, Joachim Ankerhold, and Brecht Donvil — Institute for Complex Quantum Systems and IQST, Ulm, Germany

Quantum simulation is a powerful tool to study the properties of quantum systems. The dynamics of open quantum systems are often described by completely positive (CP) maps, for which several quantum simulation schemes exist. Such maps, however, represent only a subset of a larger class of maps: the general dynamical maps which are linear, Hermitian preserving, and trace-preserving but not necessarily positivity preserving. In this talk, I show a simulation scheme for these general dynamical maps, which occur when the underlying system-reservoir model undergoes entangling (and thus non-Markovian) dynamics. Such maps also arise as the inverse of CP maps, which are commonly used in error mitigation. Our simulation scheme is illustrated on an IBM quantum processor, demonstrating its ability to recover the initial state of a Lindblad evolution. This paves the way for a novel form of quantum error mitigation. Our scheme only requires one ancilla qubit as an overhead and a small number of one and two-qubit gates. Consequently, we expect it to be of practical use in near-term quantum devices.

TT 92.4 Fri 11:30 A 151

Generalisation of the Landauer-Buettiker theory onto the case of dissipative contacts — •Andrey Kolovsky — Krasnoyarsk, Russia

We revisit the problem of two-terminal transport of non-interacting Fermi particles in a mesoscopic device by employing the semi-microscopic model for the contacts, where we mimic the self-thermalisation property of the contacts by using the Lindblad relaxation operators. It is argued that the dissipative dynamics of the contacts causes partial decoherence of the quantum states of fermionic carriers in the device which, in its turn, can essentially modify the system conductance as compared to predictions of the standard Landauer-Buettiker theory.

TT 92.5 Fri 11:45 A 151

Iterative construction of conserved quantities in dissipative nearly integrable systems — •Iris Ulčakar[1,2] and Zala Lenarčič[1] — [1]Jožef Stefan Institute, 1000 Ljubljana, Slovenia — [2]University of Ljubljana, Faculty for physics and mathematics, 1000 Ljubljana, Slovenia

Integrable systems offer rare examples of solvable many-body problems in the quantum world. Due to the fine-tuned structure, their realization in nature and experiment is never completely accurate, therefore effects of integrability are observed only transiently. One way to surpass that is to couple nearly integrable systems to baths and driving: these will stabilize integrable effects up to arbitrary time, as encoded in the time dependent, and eventually, the stationary state of form of a generalized Gibbs ensemble. However, the description of such driven dissipative nearly integrable models is challenging and no exact analytical methods have been proposed so far. Here we develop an iterative scheme in which integrability breaking perturbations (baths) determine the most necessary conserved quantities to be added into a truncated generalized Gibbs ensemble description. Our scheme significantly reduces the complexity of the problem, paving the way for thermodynamic results.

TT 92.6 Fri 12:00 A 151

Quantum thermodynamics of impurity models using the principle of minimal dissipation — •Salvatore Gatto, Alessandra Colla, Heinz-Peter Breuer, and Michael Thoss — University of Freiburg

Quantum thermodynamics has witnessed significant attention and advancement in recent years. A central challenge in this field revolves around establishing a consistent and universally accepted definition for work, heat, and entropy production in open quantum systems subjected to thermal reservoirs. Despite numerous proposals, the absence of generally accepted definitions, particularly in scenarios involving strong interactions between the system and reservoirs, remains a contentious issue. A recently developed approach, known as principle of minimal dissipation [1], leads to a unique decomposition of the quantum master equation into coherent and dissipative dynamics, allowing to identify uniquely the contributions describing work and heat.

In this contribution, we apply this approach to investigate the thermodynamic characteristics of impurity models, with a particular focus on memory effects and strong system-bath couplings. The study uses the hierarchical equations of motion approach, which allows a numerically exact simulation of nonequilibrium transport in general open quantum systems involving multiple bosonic and fermionic environments [2].

[1] A. Colla and H. Breuer, Phys. Rev. A 105, 052216 (2022)

[2] J. Bätge, Y. Ke, C. Kaspar, and M. Thoss, Phys. Rev. B 103, 235413 (2021)

TT 92.7 Fri 12:15 A 151

Control phase transitions analysis in the quantum control landscape — •Nicolò Beato, Pranay Patil, and Marin Bukov — Max Planck Institute for the Physics of Complex Systems, Noethnitzer Str. 38, 01187 Dresden, Germany

In recent years, the presence of control phase transitions emerged while numerically surveying the quantum control landscape associated with population-transfer problems in few-qubit systems [10.1103/PhysRevX.8.031086]. Despite all efforts, an analytical understanding of quantum optimal control landscapes is largely missing.

In this work, we present a set of perturbative methods that allow for the analytical characterization of various control phase transitions. These methods provide an explicit mapping between quantum control problems and classical many-body systems at thermal equilibrium (exhibiting long-range, multi-body interactions). We demonstrate the effectiveness of these approaches by explicitly considering the single- and two- qubit state-preparation problems, previously extensively studied via numerical optimization algorithms [10.1103/PhysRevA.97.052114]. Through this approach, control phase transitions are connected to dramatic changes in the topological and geometrical properties of the near-optimal part of the control landscape.

The methods developed are largely independent from the quantum systems underlying the control problem and can be easily adapted to more complicated settings. Our work shed new light on the close connection between optimal quantum control and (spin) glassy systems.

TT 92.8 Fri 12:30 A 151

Engineering unsteerable quantum states with active feedback — •Samuel Morales[1], Yuval Gefen[2], Igor Gornyi[3,4], Alex Zazunov[1], and Reinhold Egger[1] — [1]Institut für Theoretische Physik, Heinrich-Heine-Universität, 40225 Düsseldorf, Germany — [2]Department of Condensed Matter Physics, Weizmann Institute, 7610001 Rehovot, Israel — [3]Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany — [4]Institut für Theorie der Kondensierten Materie, Karlsruhe Institute of Technology, 76128 Karlsruhe, Germany

We propose active steering protocols for quantum state preparation in quantum circuits where each system qubit is connected to a single detector qubit, employing a simple coupling selected from a small set of steering operators. The decision is made such that the expected cost-function gain in one time step is maximized. We apply these protocols to several many-qubit models. Our results are underlined by three remarkable insights. First, we show that the standard fidelity does not give a useful cost function; instead, successful steering is achieved by including local fidelity terms. Second, although the steering dynamics acts on each system qubit separately, entanglement in the generated target state is introduced, and can be tuned at will, by performing Bell measurements on detector qubit pairs after every time step. This implements a weak-measurement variant of entanglement swapping. Third, numerical simulations suggest that the active steering protocol can reach arbitrarily designated target states, including passively unsteerable states such as the N-qubit W state.

TT 92.9 Fri 12:45 A 151

Extended Hilbert Space for Discontinuous Floquet Drives in the Walsh Basis — •James Walkling and Marin Bukov — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

The form of the Floquet counterdiabatic protocol has recently been found and formulated in terms of a variational principle. While good convergence is achieved in a number of systems for harmonic drives, for step drives, the convergence of the numerics is poorly behaved. As a result, we explore a reformulation of Floquet Hilbert space in terms of a more natural basis for step drives: the Walsh basis. Among other nice properties, this basis forms a group for certain finite truncations. We investigate the results of this change of basis on the overall Hamiltonian in the extended space.