FM 35: Entanglement: Many-Body Dynamics I

Time: Tuesday 14:00–16:00 Location: 2004

FM 35.1 Tue 14:00 2004

Evolution of quantum coherence — •Jan Sperling[1,2] and Ian Walmsley[2,3] — [1]University of Paderborn, Warburger Str. 100, 33098 Paderborn, Germany — [2]Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU, UK — [3]Imperial College London, Exhibition Road, London SW7 2AZ, UK

Quantum interference phenomena have been identified as a versatile resource for quantum information processing, leading to the notion of quantum coherence. In this contribution, we discuss the concept of temporal quantum coherence. In contrast to the commonly applied input-output formalism, we assess the quantum coherence of a process by deriving equations of motions for the classical, i.e., incoherent, evolution of a system. When compared to the quantum dynamics, this approach enables us to study the quantum properties of a system's evolution itself, independently of or in conjunction with the coherence of initial and final states. As an example, we apply our theoretical framework to characterize the dynamics of entanglement, being one form of quantum coherence, in correlated many-body systems.

FM 35.2 Tue 14:15 2004

Entanglement-ergodic quantum systems equilibrate exponentially well — •Henrik Wilming[1], Marcel Goihl[2], Ingo Roth[2], and Jens Eisert[2] — [1]Institute for Theoretical Physics, ETH Zurich, 8093 Zurich, Switzerland — [2]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin, Germany

One of the outstanding problems in non-equilibrium physics is to precisely understand when and how physically relevant observables in many-body systems equilibrate under unitary time evolution. General equilibration results show that equilibration is generic in interacting systems provided that the initial state has overlap with sufficiently many energy levels. But strong results not referring to typicality which show that natural initial states actually fulfill this condition are lacking. In this work, we present stringent results for equilibration for systems in which Rényi entanglement entropies in energy eigenstates with finite energy density are extensive for at least some, not necessarily connected, sub-system. Our results reverse the logic of common arguments, in that we derive equilibration from a weak condition akin to the eigenstate thermalization hypothesis, which is usually attributed to thermalization in systems that are assumed to equilibrate in the first place.

FM 35.3 Tue 14:30 2004

Quantum walk with entangled qubits — •Shahram Panahiyan and Stephan Fritzsche — Helmholtz-Institut Jena, Jena, Germany

In this talk, we discuss how arbitrary number of entangled qubits affects properties of quantum walk. We consider variance, positions with non-zero probability density and entropy as criteria to determine the optimal number of entangled qubits in quantum walk. We point it out that for a single walker in one-dimensional position space, walk with three entangled qubits show better efficiency in considered criteria comparing to the walks with other number of entangled qubits. We also confirm that increment in number of the entangled qubits results into significant drop in variance of probability density distribution of the walker, change from ballistic to diffusive (suppression of quantum propagation), localization over specific step-dependent regions (characteristic of a dynamical Anderson localization) and reduction in entropy on level of reaching the classical walk's entropy or even smaller (attain deterministic behavior).

FM 35.4 Tue 14:45 2004

Stabilizing a dissipative discrete time crystal — Droenner Leon[1], •Finsterhölzl Regina[1], Heyl Markus[2], and Carmele Alexander[1] — [1]Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187, Dresden, Germany

Experimental evidence of time reversal symmetry breaking in many-body Floquet systems has led to the discovery of a new phase of matter out-of-equilibrium, the so called discrete time crystal (DTC) [1]. The DTC shows periodic oscillations with an integer number of the Floquet period. An essential ingredient is random disorder such that the system is many-body localized (MBL) to remain out-of-equilibrium due to the suppression of entanglement growth within the isolated many-body system.

In case of an open quantum system, dissipation naturally melts the DTC [2]. However, we are able to stabilize the DTC against dissipation by coupling it to a non-Markovian bath making use of quantum feedback dynamics. Similar to MBL for the isolated system, the idea is to suppress entanglement growth with external degrees of freedom. With this, the oscillations become independent of the coupling to the environment. Our numerical simulations are based on tensor network methods which enable us to efficiently access this large Hilbert space.

[1] J. Zhang et al, Nature 543, 217-220 (2017). [2] A. Lazarides and R. Moessner, Phys. Rev. B 95, 195135 (2017). [3] L. Droenner, R. Finsterhölzl, M. Heyl, A. Carmele, arXiv:1902.04986 [quant-ph] 2019.

FM 35.5 Tue 15:00 2004

Stabilizing a dissipative discrete time crystal — Droenner Leon[1], •Finsterhölzl Regina[1], Heyl Markus[2], and Carmele Alexander[1] — [1]Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187, Dresden, Germany

Experimental evidence of time reversal symmetry breaking in many-body Floquet systems has led to the discovery of a new phase of matter out-of-equilibrium, the so called discrete time crystal (DTC) [1]. The DTC shows periodic oscillations with an integer number of the Floquet period. An essential ingredient is random disorder such that the system is many-body localized (MBL) to remain out-of-equilibrium due to the suppression of entanglement growth within the isolated many-body system.

In case of an open quantum system, dissipation naturally melts the DTC [2]. However, we are able to stabilize the DTC against dissipation by coupling it to a non-Markovian bath making use of quantum feedback dynamics. Similar to MBL for the isolated system, the idea is to suppress entanglement growth with external degrees of freedom. With this, the oscillations become independent of the coupling to the environment. Our numerical simulations are based on tensor network methods which enable us to efficiently access this large Hilbert space.

[1] J. Zhang et al, Nature 543, 217-220 (2017). [2] A. Lazarides and R. Moessner, Phys. Rev. B 95, 195135 (2017). [3] L. Droenner, R. Finsterhölzl, M. Heyl, A. Carmele, arXiv:1902.04986 [quant-ph] 2019.

FM 35.6 Tue 15:15 2004

Reversible quantum information spreading in many-body systems near criticality — •Benjamin Geiger, Quirin Hummel, Juan-Diego Urbina, and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg

Quantum chaotic interacting N-particle systems are assumed to show fast and irreversible spreading of quantum information on short (Ehrenfest) time scales $\sim \log N$. Here we show that, near criticality, certain many-body systems exhibit fast initial scrambling, followed subsequently by oscillatory behavior between reentrant localization and delocalization of information in Hilbert space. Specifically, we consider quantum critical bosonic systems with attractive contact interaction that exhibit locally unstable dynamics in the corresponding many-body phase space of the large-N limit. Semiclassical quantization of the latter accounts for many-body correlations in excellent agreement with simulations. Most notably, it predicts an asymptotically constant local level spacing $\sim 1/\tau$, again given by $\tau \sim \log N$, if the quantum phase transition is driven by a single (slow) degree of freedom. This unique timescale governs the long-time behavior of out-of-time-order correlators and entanglement entropies that, in certain scenarios, feature quasi-periodic recurrences indicating reversibility.

FM 35.7 Tue 15:30 2004

Quantification of quantum dynamics with input-output games — Roope Uola[1], •Tristan Kraft[2], and Alastair Abbott[1] — [1]Département de Physique Appliquée, Université de Genève, CH-1211 Genève, Switzerland — [2]Naturwissenschaftlich-Technische Fakultät, Universität Siegen, Walter-Flex-Str. 3, D-57068 Siegen, Germany

Recent developments regarding resource theories have shown that any quantum state or measurement resource, with respect to a convex (and compact) set of resourceless objects, provides an advantage in a tailored subchannel or state discrimination task, respectively. Here we show that an analogous, more general result is also true in the case of dynamical quantum resources, i.e., channels and instruments. In the scenario we consider, the tasks associated to a resource are input-output games. The advantage a resource provides in these games, in terms of success probability, is naturally quantified by a generalized robustness measure. We illustrate our approach by applying it to a broad collection of examples, including classical and measure-and-prepare channels, measurement and channel incompatibility. We finish by showing that our approach generalizes to higher-order dynamics where it can be used, for example, to witness causal properties of supermaps.

FM 35.8 Tue 15:45 2004

Many-body effects in cold molecules using phase-modulated two-dimensional coherent spectroscopy — •Friedemann Landmesser, Ulrich Bangert, Lukas Bruder, Marcel Binz, Daniel Uhl, and Frank Stienkemeier — Institute of Physics, University of Freiburg, Germany

Many-body quantum states are considered to play a crucial role in atomic and molecular systems with respect to dissipation as well as excitation and energy transfer processes [1]. We aim to investigate collective effects in organic molecules by means of multiple-quantum coherence experiments where multiphoton processes can be separated from one-photon transitions and can be assigned to specific particle numbers [2,3]. In a first step, we will adapt a detection scheme that is based on phase-modulated two-dimensional coherent spectroscopy and which was already used to investigate multi-atom Dicke states in potassium vapor [3,4]. Measurements on a rubidium vapor will serve as a benchmark. In a second step, collective effects in organic molecular systems will be studied. To this end, we will adapt our helium nanodroplet source to produce solid rare gas clusters, that can be doped with hundreds of organic molecules. The cluster surface acts as a well-defined, cold environment [5]. In lifetime measurements we already identified collective effects of the interacting molecules at increasing doping densities [5].