DY 53: Many-body Quantum Dynamics II (joint session DY/TT)

Time: Thursday 15:00–16:30 Location: HÜL/S186

DY 53.1 Thu 15:00 HÜL/S186

general framework for understanding and modeling irreversibility: relaxator Liouville dynamics — •Martin Janssen and Janos Hajdu — Institut für Theoretische Physik, Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Germany

Irreversibility is explained as an emergent phenomenon brought about by a separation between two characteristic time scales: the time t_s up to which relevant degrees of freedom of a system are tracked is extremely much shorter than the spectral resolution time t_e necessary to resolve the spectrum of all degrees of freedom involved. A relaxator that breaks reversibility condenses in the Liouville operator of the relevant degrees of freedom. The irrelevant degrees of freedom act as an environment. The relaxator Liouville equation is a most general equation of motion in a many body quantum system and contains memory effects and initial correlations of all degrees of freedom, generalizing the well known semi-group dynamics. Stationary states turn out to be generically unique and independent of the initial conditions and exceptions are due to degeneracies. Equilibrium states lie in the relaxator's kernel yielding a stationary Pauli master equation and a non negative entropy production rate is identified. Kinetic equations for one-particle densities are constructed as special cases and Kubo's linear response theory is generalized to relaxator Liouville dynamics. In weak coupling between system and environment the relaxator can be factorized in environmental correlations and bilinear system operators.

DY 53.2 Thu 15:15 HÜL/S186

Ground-State Exploration Driven by Thermal and Quantum Fluctuations — •Yoshiaki Horiike[1] and Yuki Kawaguchi[1,2] — [1]Department of Applied Physics, Nagoya University, Nagoya, Japan — [2]Research Center for Crystalline Materials Engineering, Nagoya University, Nagoya, Japan

Simulated annealing provides a heuristic solution to combinatorial optimization problems. The cost function of a problem is mapped onto the energy function of a physical many-body system, and, by using thermal or quantum fluctuations, the system explores the state space to find the ground state, which may correspond to the optimal solution of the problem. Studies have highlighted both the similarities and differences between thermal and quantum fluctuations. Nevertheless, fundamental understanding of thermal and quantum annealing remains incomplete, making it unclear how quantum annealing outperforms thermal annealing. Here, we investigate the many-body dynamics of thermal and quantum annealing by examining all possible interaction networks of $\pm J$ Ising spin systems up to seven spins. Our comprehensive investigation reveals that differences between thermal and quantum annealing become prominent for particular interaction networks, indicating that the structure of the energy landscape distinguishes the two dynamics. We identify the microscopic origin of these differences through probability fluxes in state space, finding that the two dynamics are broadly similar but that quantum tunnelling produces qualitative differences. (arXiv:2511.16457)

DY 53.3 Thu 15:30 HÜL/S186

Symmetry re-breaking in an effective theory of quantum coarsening — •Federico Balducci[1], Anushya Chandran[2], and Roderich Moessner[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden — [2]Boston University, Boston, MA

We present a simple theory accounting for two central observations in a recent experiment on quantum coarsening and collective dynamics on a programmable quantum simulator [T. Manovitz et al., Nature 638, 86 (2025)]: an apparent speeding up of the coarsening process as the phase transition is approached; and persistent oscillations of the order parameter after quenches within the ordered phase. Our theory, based on the Hamiltonian structure of the equations of motion in the classical limit of the quantum model, finds a speeding up already deep within the ordered phase, with subsequent slowing down as the domain wall tension vanishes upon approaching the critical line. Further, the oscillations are captured within a mean-field treatment of the order parameter field. For quenches within the ordered phase, small spatially-varying fluctuations in the initial mean-field lead to a remarkable long-time effect, wherein the system dynamically destroys its long-range order and has to coarsen to re-establish it. We term this phenomenon symmetry re-breaking, as the resulting late-time magnetization can have a sign opposite to the initial magnetization.

DY 53.4 Thu 15:45 HÜL/S186

Pairing-induced phase transition in the non-reciprocal Kitaev chain — •Pietro Brighi and Andreas Nunnenkamp — Faculty of physics, University of Vienna, Boltzmanngasse 5, 1090, Vienna, Austria

Investigating the robustness of non-reciprocity in the presence of competing interactions is central to understanding non-reciprocal quantum matter. In this work, we use reservoir engineering to induce non-reciprocal hopping and pairing in the fermionic Kitaev chain, and reveal the emergence of a pairing-induced phase transition. The two phases appear in the spectrum of the non-Hermitian Kitaev Hamiltonian describing the dynamics of correlations, separated by an exceptional point. In the non-reciprocal phase, dynamics are characterized by directionality and slow relaxation, and the steady state supports non-reciprocal density and spatial correlations. At strong pairing, we uncover an unexpected density wave phase, featuring short relaxation times, a modulation in particle occupation and strikingly different correlation spreading depending on pairing non-reciprocity. Our work highlights the non-trivial breakdown of non-reciprocity due to superconducting pairing and invites experimental investigation of non-reciprocal fermionic systems.

DY 53.5 Thu 16:00 HÜL/S186

Harnessing spin qubit decoherence to probe strongly interacting quantum systems — Marcin Płodzień[1], •Sambunath Das[2], Maciej Lewenstein[1,3], Christina Psaroudaki[4], and Katarzyna Roszak[2] — [1]Institut de Ciencies Fotoniques, The Barcelona Institute of Science and Technology, 08860 Castelldefels (Barcelona), Spain — [2]Institute of Physics of the Czech Academy of Sciences, Na Slovance 1999/2, 182 00 Prague, Czech Republic — [3]Passeig Lluis Companys 23, 08010 Barcelona, Spain — [4]Laboratoire de Physique de l' École Normale Supérieure, Université PSL, CNRS, Sorbonne Université, Université de Paris, 75005 Paris, France

Using a mobile qubit as a probe to study the properties of a larger quantum system is a novel technique that leverages the quantum nature of the probe, the system under study, and the interaction between them [1-3]. By analyzing qubit decoherence, one accesses to properties that are difficult to measure classically. We apply this method to the anisotropic Heisenberg XXZ spin-1/2 chain, an archetypal example of strongly correlated system, and show that qubit dynamics encode key system parameters, including quantum phase transitions and perturbation propagation velocity [4]. This demonstrates the effectiveness of small quantum probes for exploring large quantum systems.

References: 1. F. Casola, T. van der Sar et al, Nat. Rev. Mat. 3, 17088 (2018). 2. J. F. Rodriguez-Nieva, K. Agarwal et al. Phys. Rev. B 98, 195433 (2018). 3. S. Chatterjee, J. F. Rodriguez-Nieva et al, Phy. Rev. B 99, 104425 (2019). 4. M Płodzień, S. Das et al, Phy. Rev. B 111, L161115 (2025).

DY 53.6 Thu 16:15 HÜL/S186

Enhancing efficiency of local-information time evolution — •Moksh Bhateja[1], Jonas Rigo[2], and Markus Schmitt[2,3] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Universität Regensburg, Regensburg, Germany — [3]PGI-8: Forschungszentrum Jülich, Jülich, Germany

The time evolution of an initially unentangled system under the von Neumann equation generally leads to rapid entanglement growth. This poses challenges for numerical tractability. The Information Lattice framework addresses this by systematically discarding accumulated non-local information (i.e., entanglement) to maintain computational feasibility. Within the local-information time evolution (LITE) approach, we propose Rényi-2 entropy as a measure of information, eliminating the need for matrix decomposition. When combined with additional approximations, this approach significantly enhances the efficiency and scalability of simulations in terms of both system size and duration of time evolution. We demonstrate the accuracy of this method by computing high-quality diffusion coefficients and local observables for a large non-integrable system.