SYAD 1: SAMOP Dissertation Prize

Time: Monday 14:30–16:30 Location: Paulussaal

Invited Talk SYAD 1.1 Mon 14:30 Paulussaal
Quantum steering of a Szilárd engine — •Konstantin Beyer — Stevens Institute of Technology, Hoboken, USA — Technische Universität Dresden, Dresden, Germany

Work is one of the central concepts of classical thermodynamics. However, it has proved difficult to extend this concept unambiguously to quantum systems, especially when it comes to measuring work. Unlike in classical physics, a thermal quantum state is not a mixture of objective microstates, quantum measurements generally disturb the system, and quantum systems exhibit non-classical correlations, to name just a few of the central issues.

We illustrate these conceptual differences with the help of a quantum Szilárd engine. In the classical version of this thought experiment, a so-called Maxwell's demon extracts work from a thermal state by observing the position of a single particle in a box and applying a suitable work extraction operation. In the quantum case, the work output of the engine depends strongly on the measurement made by the demon to determine the state of the work medium.

We split the quantum Szilárd scenario into a bipartite setting. The demon is only allowed to measure the thermal environment to indirectly determine the system state. By sharing the acquired information with another agent, the latter can extract work. In a suitable setting, it can then be shown that the maximum work output of the engine can only be achieved if the thermal state of the work medium cannot be decomposed into an ensemble of objective local (hidden) states.

Invited Talk SYAD 1.2 Mon 15:00 Paulussaal
Does a disordered Heisenberg quantum spin system thermalize? — •Titus Franz — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

Isolated quantum systems prepared far from equilibrium are generally expected to show thermalization. As a notable exception to this rule, strongly disordered systems can retain retrievable memory of their initial state for arbitrarily long times, leading to a rich phenomenology ranging from glassy dynamics to many-body localization. While exact numerical simulations are not possible beyond very small system sizes, we can experimentally probe the relaxation dynamics in an isolated spin system realized by a frozen gas of Rydberg atoms. Our findings reveal an anomalously slow dynamics that is independent of the specific type of Heisenberg Hamiltonian, suggesting a universal relaxation behavior. Furthermore, we observe characteristic features in the long-time magnetization as a function of a transverse external field, including non-analytic behavior at zero field. The emergence of these distinctive features seems incompatible with the assumption of local thermalization, which indicates that even large systems of thousands of spins with long-range interactions in three dimensions have not reached thermal equilibrium even at late times when the magnetization has already fully relaxed to zero. Both phenomena, the slow and universal relaxation dynamics and the absence of thermalization at late times, point toward the emergence of localization as the overarching principle governing out-of-equilibrium dynamics of spatially disordered quantum spin systems.

Invited Talk SYAD 1.3 Mon 15:30 Paulussaal
Quantum optical few-mode models for lossy resonators — •Dominik Lentrodt — Max-Planck-Institut für Kernphysik, Heidelberg — Albert-Ludwigs-Universität Freiburg

Few-mode models — such as the Jaynes-Cummings model and its generalisations — have been an indispensable tool in studying light-matter interactions in optical resonators and provide the theoretical basis for many experiments. Recently, however, novel regimes featuring strong coupling in combination with large losses have attracted attention in various experimental platforms. In this context, central assumptions of these canonical quantum optical models break down and lead to discrepancies in observations, which constituted an open problem.

In this talk, we will discuss recent extensions of such approaches and an associated class of loss-induced multi-mode effects. We show how the open Jaynes-Cummings model can be derived from first principles, circumventing usually employed fitting procedures and resolving aforementioned discrepancies. We will further discuss how these developments have led to ab initio models for x-ray quantum optics with Mössbauer nuclei — an emerging field at the high-energy frontier of quantum optics — enabling predictions for upcoming experiments.

Invited Talk SYAD 1.4 Mon 16:00 Paulussaal
Non-Hermitian topology and directional amplification — •Clara Wanjura — Max Planck Institute for the Science of Light, Erlangen, Germany

Topology has been a major research theme in condensed matter physics and is associated with a number of remarkable phenomena such as robust edge states. A prominent example is the quantum Hall effect, in which the topological invariant is directly observable through the Hall resistance. More recently, topology started to be investigated in systems experiencing gain and loss sparking the field of non-Hermitian topology. However, so far, a clear observable signature of non-Hermitian topology had been lacking.

In this talk, I will show that non-trivial, non-Hermitian topology is in one-to-one correspondence with the phenomenon of directional amplification in one-dimensional bosonic systems, e.g., cavity arrays. Directional amplification allows to selectively amplify signals depending on their propagation direction and has attracted much attention as key resource for applications, such as quantum information processing. Remarkably, in non-trivial topological phases, the end-to-end gain grows exponentially with the number of sites. Furthermore, this effect is robust against disorder with the amount of tolerated disorder given by the separation between the complex spectrum and the origin. Our work opens up new routes for the design of multimode robust directional amplifiers and sensors based on non-Hermitian topology that can be integrated in scalable platforms such as superconducting circuits, optomechanical systems and nanocavity arrays.