Driven open quantum systems — from micro- to macrophysics

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Recent experimental developments in areas -- ranging from cold atomic gases over light driven semiconductors to NISQ platforms -- move systems into the focus, which are located on the interface of quantum optics, condensed matter physics and statistical mechanics. These systems realize instances of driven open quantum matter: Coherent and driven-dissipative quantum dynamics occur on an equal footing, and they are operated in the thermodynamic limit.

In these lectures, we will develop the tools to understand such systems based on a field theory approach to the many-body Lindblad equation, which is particularly well suited to perform the transition from microscopic physics to macroscopic observables, thereby distilling universal aspects of such setups. In particular, we will make precise in which way these systems qualify as "non-equilibrium" on the microscopic scale. Based on this understanding, we will then focus on two applications: First, we investigate the fate of the famous Kosterlitz-Thouless phase transition under driving conditions. We show that an infinitesimal non-equilibrium perturbation is sufficient to suppress this transition in large systems. On the other hand, we point out a new intrinsic non-equilibrium phase transition characterized by the onset of defect chaos. Second, we argue that drive and dissipation can be harnessed to create various forms of quantum mechanical correlations such as phase coherence, entanglement or topological order. We will concentrate on topology, and zooming out, discuss universal aspects of topology in mixed quantum states and far from equilibrium.

Reading material: https://arxiv.org/abs/1512.00637