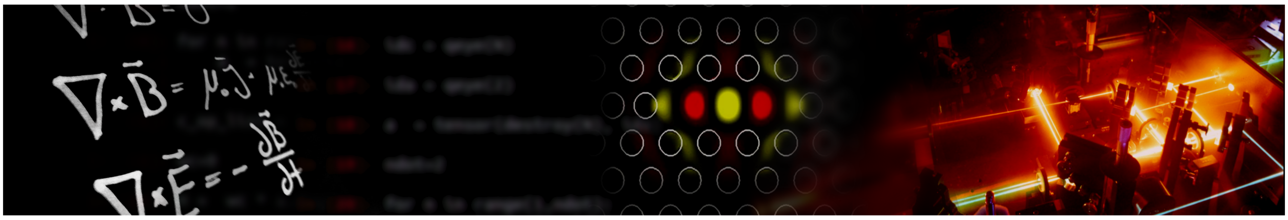

Open quantum systems theory

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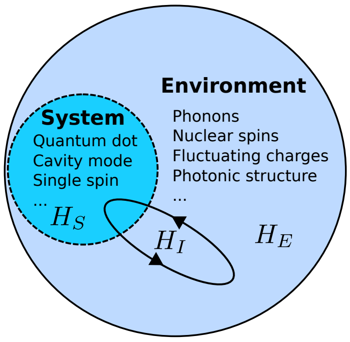

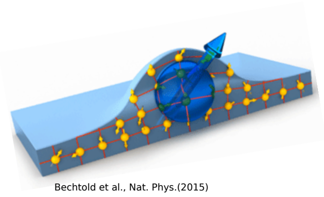

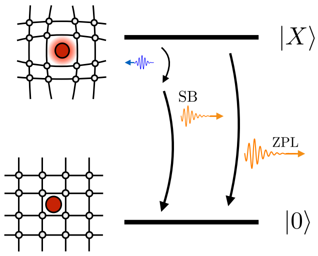

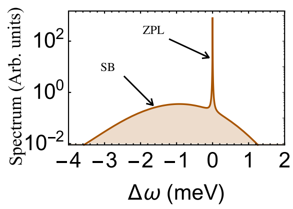

All quantum systems - from single atoms and quantum dots to microcavities and nano-mechanical resonators - interact with their surrounding environment and are thus *open* [1]. Since the environment often comprises many degrees of freedom, the dynamics of even the simplest quantum system can be become immensely rich in the presence of environmental interactions. These interactions lead to *decoherence*, which drives coherent quantum dynamics towards classical behavior. Thus, to combat decoherence, understanding open quantum systems is necessary. Open systems theory is a well-developed field with many tools to calculate physical properties arising from environmental interactions - without having to solve the full many-body dynamics! We offer a number of projects in the interface between fundamental science and applications in quantum technology:

- **The role of phonon interactions in quantum dot single photon sources** [2]. For the use in optical quantum technologies, single photon sources need to emit *indistinguishable* photons with good coherence properties. However, phonons in the atomic lattice of quantum dots degrade the coherence by stealing information and energy out of the system. Open systems theory can help us understand what consequences phonon interactions have and how to mitigate them

- **Nuclear spin dynamics and spin dephasing in relation to entanglement and spin-photon interfaces** [3]. Single electron spins in quantum dots can be used for example as quantum memories and to manipulate the polarisation state of single photons - even to generate large entangled photonic states [4]. However, a single quantum dot contains roughly 10.000-100.000 nuclear spins that couple to the electron spin and deteriorates the coherence. By understanding the interaction, we can develop new methods to protect the spin coherence against the interaction [3].

- **The influence of the surrounding photonic structures on the coherence properties of quantum emitter**. When a quantum emitter is placed in a strongly dispersive photonic structure, where the density of states is frequency dependent, the interaction between the emitter and the optical modes gives rise to interesting emission dynamics [5]. This effect can be used to control which transition processes are allowed and forbidden, which in the presence of e.g. phonon interactions can be used to improve the coherence properties of the emitted photons.

If you want to hear more about the projects, do not hesitate to come by our offices or send us an email.

- All projects are available as M.Sc., B.Sc. and special course projects.

[1] Jake Iles-Smith, *Excitation dynamics of strongly dissipative quantum systems*, Ph.D. thesis (2015)
[2] Jake Iles-Smith *et al.*, Nat. Phot. **11**, 521 (2017)
[3] Emil V. Denning *et al*., ArXiv:1706.02486 (2017)
[4] Netanel Lindner *et al.,* Phys. Rev. Lett. **103**, 113602 (2009)
[5] Kaushik Roy-Choudhury *et al.,* Optica **2**, 5 (2015)