

So, I'm a Chemist. Why should I care about non-Markovianity?

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Organic semiconductors are one of the key materials for the development of next-generation energy harvesting, transport and conversion technology. This interdisciplinary research effort, at the boundary between quantum physics and chemistry, deals with problems such as the spectral properties of interacting molecules [1], the transport of excitons in amorphous polymers [2], and the energy conversion pathways in multi-exciton processes [3].

Markovian (i.e., memoryless) quantum master equations (e.g., Lindblad) offer a tractable and commonly used approach to study many of these problems. Since decoherence happens within picoseconds in “hot and wet” media (e.g., molecules at room temperature), these master equations can further simplify to population dynamics of the system eigenstates [4]. Furthermore, in systems characterised by weak system-environment couplings, departure from Markovianity is often thought to matter only for short transients with respect to the time-scale of decoherence and relaxation. So, why should we care about non-Markovianity, when even diagonal Markovian approximations seem to be enough?

Interestingly, recent theoretical and experimental results have pointed to situations where non-Markovianity plays a crucial role even when system-environment couplings are weak, affecting the steady state solution [5]. In this talk I will discuss a few applied examples where it is not possible to approximate the dynamics with Markovian second-order perturbation theory approximations. Some key implications are steady states that deviate from thermal equilibrium, and efficient formation of transient high-energy states. I will discuss how these long-lived out-of-equilibrium states offer a pathway to efficient energy transport and conversion in organic semiconductors [6], and can find applications in other fields.

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