Relaxation and Disorder of Lossy Cavity Polaritons: Transfer Tensor Method

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Abstract

Accurate description of polaritonic dynamics requires the development of advanced numerical techniques. The transfer-tensor method (TTM) is a versatile tool for the analysis and propagation of general open quantum systems, particularly suitable for non-Markovian dynamics and strong coupling to the photon environment (1). It is based on an iterative black-box generation of a compact multiplicative propagator that uses linear resources to store all memory effects of the photon or phonon bath. The propagating tensors can efficiently predict long-time dynamics beyond the reach of sophisticated simulation methods (2,3).
We will discuss the application of this tool to a variety of polaritonic phenomena. First, we will show how it is possible to extract relaxation properties directly from the tensors without the need of actual propagation: steady state, long relaxation timescales and oscillatory behaviour (4). Then, in line with two recent additions to the method, we will present the possibility to treat static disorder with the disorder-averaged TTM (DA-TTM), and a basis reduction technique that further compresses the size of the tensors (BR-TTM) (4) based on the symmetry of polariton dynamics. Finally, these techniques provide a toolbox for characterizing the interplay of cavity loss, disorder, and cooperativity in polariton relaxation and allow us to predict unusual dependences of polariton relaxation on the initial excitation state, photon decay rate, strength of disorder, and the type of cavity models.

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