LINDBLAD MASTER EQUATION CAPABLE OF DESCRIBING HYBRID QUANTUM SYSTEMS IN THE ULTRA-STRONG COUPLING REGIME

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Light-matter interaction between confined electromagnetic fields formed in cavities and quantum emitters is of great interest because it allows to change the fundamental properties of the hybrid systems constituents. This topic has been already widely investigated for different types of systems ranging from cold atoms in optical cavities [1,2] to superconducting qubit-oscillator circuits [3]. However, despite a large theoretical effort devoted to considering light-matter interaction in different regimes, the so-called ultra-strong coupling regime [4] still presents significant challenges for theoretical treatments and prevents the use of many common approximations. In the present work, we demonstrate why the standard methods fail from a novel perspective and propose a model that can describe hybrid systems to any level of accuracy for an arbitrary electromagnetic environment and any coupling regime. We extend an approach developed in our group for few-mode quantization of arbitrary systems [5] to the case of large light-matter coupling constants and/or ultrabroad-bandwidth resonances and show that even such systems can be treated using a Lindblad master equation where decay operators act only on the photonic degrees of freedom. We also provide a comparison with state-of-the-art master equation approaches, which show quite noticeable disagreement with our model for the considered problems.

References:

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