

TITLE

Yang Zhao

^a School of MSE, Nanyang Technological University, Singapore, Singapore

✉ yzhao@ntu.edu.sg

Lindblad master equations describing driven quantum systems coupled to multiple bosonic modes are central to modeling cavity quantum electrodynamics and pseudomode models. In this work, we employ the density-operator-based Dirac–Frenkel time-dependent variational principle combined with the multiple Davydov D_2 Ansatz to provide optimal solutions for Lindblad master equations in both multimode and driven scenarios. Our approach is benchmarked against numerically “exact” methods in two representative models. The first describes a driven qubit subject to spontaneous emission and coupled to a lossy cavity, while the second corresponds to the pseudomode Lindblad master equation derived from the driven spin-boson model, incorporating seven discrete pseudomodes. The proposed variational approach achieves excellent agreement with numerically “exact” results. Furthermore, we analyze the accuracy of the variational solutions using an error metric based on the Frobenius norm, confirming their reliability. Overall, the present method offers an accurate and computationally efficient framework for simulating Lindblad master equations in complex open quantum systems.

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