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Dissipative dynamics in the deep strong coupling regime

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The quantum Rabi model, describing the interaction of a two-level system and a quantized single mode beyond the rotating-wave approximation, has found an experimental playground with the advent of novel technologies. The impressive progress on superconducting circuits [1] have produced the largest light-matter coupling ever observed. In this sense, the ultrastrong coupling (USC) regime happens when the coupling strength g is comparable to appreciable fractions of the oscillator frequency $0.1 \leqslant g/\omega \leqslant 1$.
Moreover, it is expected that these architectures can reach soon the deep strong coupling (DSC) regime, where $g/\omega \geqslant 1$. These regimes are unattainable for the usual experiments in quantum optics, be in trapped ions or cavity QED setups [2]. The DSC regime predicts the appearance of a different kind of collapses and revivals of the photon statistics, which are explained as photon number wave packets propagating along two independent parity chains [3]. From this point of view, it would be of fundamental interest to study these key features, and possible analytical solutions in presence of dissipation.
In this work, we study the DSC regime of the quantum Rabi model in presence of mode dissipation and we present our model showing that a zero-temperature Markovian bath drives the system to an incoherent mixture of two parity chains [4]. A numerical analysis is provided and it gives insights for the non-solvable case of near-resonance regime.

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