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Reconciling quantum and classical spectral theories of ultrastrong coupling: role of cavity bath coupling and gauge corrections: erratum

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This erratum contains typographical corrections to our recent paper [Opt. Quantum 2, 133 (2024)]. These corrections do not alter any of our previous results and conclusions.

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In our recent paper [1], we noticed small typographical errors in the renormalized dipole frequency and atom-cavity coupling rate for finite cavity-emitter detunings, which should read $\tilde{\omega}_0 = \omega_0(1 + 4\eta^2\omega_c/\omega_0)$ and $\tilde{g}^2 = g^2/(1 + 4\eta^2\omega_c/\omega_0)^{\frac{1}{2}}$. In addition, the g^2 appearing in Eq. (5) should be replaced by $g^2\omega_0/\omega_c$. No results in our paper are affected by this change, and the resonance frequencies between quantum and classical models agree as stated.

Additionally, we described the quadrature coupling $\Pi_c = (Q \pm P)/\sqrt{2}$ in the system-reservoir Hamiltonian as "phase-insensitive." Although this coupling is symmetric with regards to the Q and P quadratures, it is not phase-insensitive, which can be verified by considering a unitary transformation which changes the phase of the cavity operators. However, an alternative form of the coupling Hamiltonian which *is* phase-insensitive is $\Pi_c = a$. We did not consider this form in the paper, but in fact we find that it gives almost identical results to those of the quadrature choices $(Q \pm P)/\sqrt{2}$, which we show in Fig. 1 (with normalized coupling rate $\eta = g/\omega_c = 0.5$), and thus also exhibits correspondence with the classical model in the ultrastrong coupling regime.

As such, our argument about phase-insensitive phenomenological couplings giving correspondence with the classical phase-insensitive phenomenological dissipation model remains accurate, though it should be more properly interpreted as applying to the coupling operator choice $\Pi_c = a$, which also arises naturally in the recently proposed ab initio theory of loss in quantized cavities [2].

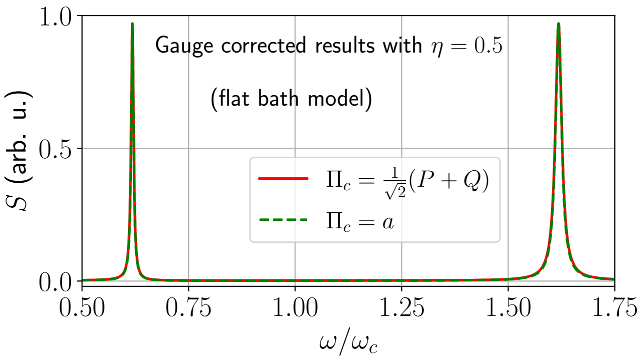

Fig. 1. Example spectra computed for the quantized harmonic oscillator emitter coupled to a cavity mode, with $g = 0.1$ and $\kappa = 0.05g$, but now showing $\Pi_c = a$ as well as $\Pi_c = (Q + P)/\sqrt{2}$ [which yields the same answer as $\Pi_c = (Q - P)/\sqrt{2}$]. We can see that these models are in agreement, and thus both models also agree with the classical spectral results as shown in our original article [1].

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Disclosures. The authors declare no conflicts of interest.

Data availability. Data underlying the results presented in this paper are not publicly available at this time but may be obtained from the authors upon reasonable request.

REFERENCES

1. S. Hughes, C. Gustin, and F. Nori, "Reconciling quantum and classical spectral theories of ultrastrong coupling: role of cavity bath coupling and gauge corrections," Opt. Quantum **2**, 133–139 (2024).
2. C. Gustin, J. Ren, S. Franke, *et al.*, "Dissipation in the broadband and ultrastrong coupling regimes of cavity quantum electrodynamics: an ab initio quantized quasinormal mode approach," arXiv (2025).