Erratum: Manipulating quantum materials with quantum light [Phys. Rev. B 99, 085116 (2019)]

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The interaction Hamiltonian $\hat{V}$ in Eq. (14) describing the interaction between the cavity and the electronic system was obtained by expanding the Peierls Hamiltonian in Eq. (A4) up to first order in the small parameter η. All results presented in the paper are consistent with this approximate interaction Hamiltonian, leading to an effective Hamiltonian that depends quadratically on η. However, it turns out that a straightforward improvement of the parameters entering the effective Hamiltonian in Eq. (26) can be obtained by including the second-order term in the Peierls Hamiltonian in Eq. (A4). This term gives rise to modifications of our results that are also of order η^2 through a renormalization of the nearest-neighbor hopping amplitude t.

More specifically, when expanding Eq. (A4) up to second order in η, the photon-electron interaction Hamiltonian reads

$$\hat{V} = g(\hat{a} + \hat{a}^\dagger)\hat{\mathcal{J}} - \frac{1}{2}\frac{g^2}{t^2}(\hat{a} + \hat{a}^\dagger)^2\hat{T}, \tag{15}$$

where $\hat{\mathcal{J}}$ and $\hat{T}$ are the dimensionless current operator and the hopping term defined in Eqs. (15) and (5), respectively. The perturbation Hamiltonian $\hat{H}_1$ in Eq. (18) can then explicitly be written as

$$\hat{H}_1 = \hat{T} + \hat{V} = \left[1 - \frac{1}{2}\frac{g^2}{t^2}(\hat{a} + \hat{a}^\dagger)^2\right]\hat{T} + g(\hat{a} + \hat{a}^\dagger)\hat{\mathcal{J}}, \tag{18}$$

and the additional term in Eq. (15) makes the term in square brackets in front of $\hat{T}$ in Eq. (18) different from unity.

Repeating the derivation of the effective Hamiltonian with the revised expressions in Eqs. (15) and (18) and keeping only terms up to order η^2 modifies our results as follows. First, the presence of the cavity reduces the hopping amplitude t such that the effective Hamiltonian reads:

$$\hat{H}_{\text{gs}} = \hat{H}[t_c J_c \alpha_c] + \hat{\mathcal{P}}_0(\hat{H}_{\text{shift}} + \hat{H}_{\text{2-site}} + \hat{H}_{\text{long}})\hat{\mathcal{P}}_0, \tag{26}$$

where $t_c = t[1 - g^2/(2t^2)]$. Second, the parameters J_c and α_c are now given by

$$J_c = J\left(1 - \frac{g^2}{t^2} + \mathcal{C}\right), \tag{27a}$$

$$\alpha_c = \alpha\frac{1 - \frac{g^2}{t^2} - \mathcal{C}}{1 - \frac{g^2}{t^2} + \mathcal{C}}. \tag{27b}$$

The parameter $\mathcal{C} = (g^2/t^2)U/(U + \Omega)$ in Eq. (28) remains unchanged, and the pair hopping amplitude is

$$\alpha_c J_c = \alpha J\left(1 - \frac{g^2}{t^2} - \mathcal{C}\right). \tag{29}$$

Equation (27a) shows that the cavity *reduces* the magnetic interaction J_c for all values of $g > 0$, which contradicts our previous claim that J_c is enhanced.

The second term $\hat{\mathcal{P}}_0(\cdots)\hat{\mathcal{P}}_0$ in Eq. (26) remains unchanged, and all our other conclusions remain unchanged. In particular, we verified that the results of the ground-state calculations in Sec. III B acquire only a small correction due to the rescaled hopping amplitude. When revisiting these calculations we noticed an error in Eq. (33) defining the momentum-space electron correlations which should read

$$N(q_1, q_2) = \langle c^\dagger_{q_1,\uparrow}c_{q_1,\uparrow}c^\dagger_{q_2,\downarrow}c_{q_2,\downarrow}\rangle - \langle c^\dagger_{q_1,\uparrow}c_{q_1,\uparrow}\rangle\langle c^\dagger_{q_2,\downarrow}c_{q_2,\downarrow}\rangle. \tag{33}$$

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