

Erratum: Formation of a Spin Texture in a Quantum Gas Coupled to a Cavity **[Phys. Rev. Lett. 120, 223602 (2018)]**

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We correct the errors in the signs or definitions of some quantities and their associated expressions. As described below, these corrections either do not change our results or modify them slightly, thus leaving all conclusions of the paper unchanged.

(1) In our calculations of vectorial atom-light coupling, we made two different sign mistakes that together cancel each other.

(a) By following [1,2] we realized that the sign of vectorial polarizability was wrong. Hence, the ratio of vectorial and scalar polarizability α_v/α_s should be -0.928 . In the Supplemental Material, the ratio $\alpha_v/(2\alpha_s)$ should also be accordingly corrected to -0.464 . Note that our sign convention of $\hat{a}$ is reversed as compared to [1].

(b) While transforming from the generalized Eqs. (6)–(10) depicting atom-light coupling to Eq. (11) in the Supplemental Material, we made a mistake in the sign of the term illustrating the vectorial atom-light coupling induced by the transverse pump and the cavity field. We reiterate the corrected Eq. (11) here:

$$\hat{H}_{\text{int}}^{(2)} = \frac{1}{4}\alpha_s f^2(\hat{\mathbf{x}})E_p^2 + \alpha_s g^2(\hat{\mathbf{x}})E_0^2 \hat{a}^\dagger \hat{a} + \frac{1}{2}f(\hat{\mathbf{x}})g(\hat{\mathbf{x}})E_p E_0 \left[\alpha_s \boldsymbol{\epsilon}_p \cdot \boldsymbol{\epsilon}_c (\hat{a}^\dagger + \hat{a}) + i \frac{\alpha_v}{2F} \boldsymbol{\epsilon}_p \times \boldsymbol{\epsilon}_c \cdot \hat{\mathbf{F}} (\hat{a}^\dagger - \hat{a}) \right]. \quad (1)$$

As a result, the sign of the vectorial coupling term in Eq. (15) of the Supplemental Material must be changed to the following:

$$i \frac{\alpha_v}{2F} (\hat{a}^\dagger - \hat{a}) m_F \sin \varphi \rightarrow -i \frac{\alpha_v}{2F} (\hat{a}^\dagger - \hat{a}) m_F \sin \varphi. \quad (2)$$

Correspondingly, the definition of the coupling energy $\hbar\lambda_{v,m_F}$ is modified to $\hbar\lambda_{v,m_F} = -M_0(V_{\text{TP}})E_p E_0 \alpha_v \sqrt{N_{m_F}}/(2F)$. This also changes the definition of the critical angle φ_c for equal scalar and vectorial coupling in a spin mixture. This is presented in Eq. (10) of the main text and in the “Phase boundaries for a spin mixture” section of the Supplemental Material. The corrected definition is

$$\varphi_c = \arctan \left(-\frac{2\alpha_s}{\alpha_v} \right). \quad (3)$$

Eq. (1) also results in a change in the sign of vectorial polarizability term in the definition of the dipole operator in Eq. (1) of the main text as

$$\hat{\mathbf{d}} = \hat{\mathbf{d}}_s + i\hat{\mathbf{d}}_v = -\frac{\alpha_s}{2}\hat{\mathbf{E}} - i\frac{\alpha_v}{4F}\hat{\mathbf{F}} \times \hat{\mathbf{E}}. \quad (4)$$

Eqs. (29)–(32) of the Supplemental Material also need to be corrected by replacing $\alpha_v/(2\alpha_s)$ with $-\alpha_v/(2\alpha_s)$.

The effect of all the sign changes discussed in (b) is canceled by the sign change of α_v . Hence, our theoretical predictions for the direction of vectorial component of the induced dipole (Figs. 1 and 2 of the main text), the phase of the cavity field in the case of different Zeeman states (Fig. 3 of the main text), and the critical polarization angle for a spin mixture (Fig. 4 of the main text) are unchanged.

(2) In Eq. (15) of the Supplemental Material, U_0 should be replaced by $\hbar U_0$. The corrected equation is

$$\hat{H}_{\text{BEC}} = -\left(\hbar\Delta_c - \hbar\frac{NU_0}{2}\right)\hat{a}^\dagger\hat{a} + \sum_{m_F} E(V_{\text{TP}})|k\rangle\langle k|_{m_F} + M_0(V_{\text{TP}})E_p E_0 \left[\alpha_s(\hat{a}^\dagger + \hat{a}) \cos\varphi - i\frac{\alpha_v}{2F}(\hat{a}^\dagger - \hat{a})m_F \sin\varphi \right] \hat{J}_{x,m_F}. \quad (5)$$

As a result, the definition of effective detuning $\tilde{\Delta}_c$ below Eq. (16) is rectified and also corrected for a wrong sign. The corrected definition is

$$\tilde{\Delta}_c = \Delta_c - \frac{NU_0}{2}.$$

(3) In the “Transition point for a single spin component” section of the Supplemental Material, the definition of the transition point λ_c was incorrect. The corrected expression of the critical point of the Dicke model [3] as obtained from Eq. (3) of the main text after the phase transformation $\hat{a} \rightarrow \hat{a}e^{-i\phi_{m_F}}$ is

$$\lambda_c = \sqrt{(\tilde{\Delta}_c^2 + \kappa^2)\omega_0/(-\tilde{\Delta}_c)}.$$

As a result, Eq. (19) in the Supplemental Material showing the critical pump lattice depth is corrected to

$$\frac{M_0^2(V_{\text{TP},c})V_{\text{TP},c}}{\hbar\omega_0(V_{\text{TP},c})} = \frac{\tilde{\Delta}_c^2 + \kappa^2}{4\tilde{\Delta}_c U_0 N_{m_F} (\cos^2\varphi + (\frac{\alpha_v m_F}{2F\alpha_s})^2 \sin^2\varphi)}. \quad (6)$$

and accordingly Eq. (6) in the main text is modified to

$$V_{\text{TP}}^c = \frac{\hbar\omega_0(\tilde{\Delta}_c^2 + \kappa^2)}{4NM_0^2\tilde{\Delta}_c U_0} \frac{1}{\cos^2\varphi + (\frac{\alpha_v m_F}{2F\alpha_s})^2 \sin^2\varphi}. \quad (7)$$

In our fitting method for the self-organization threshold, the dependence on detuning $\tilde{\Delta}_c$ and the constants is encapsulated by an overall scaling factor c . So, this mistake does not modify our results.

(4) In the “Accounting for collisional atomic interactions” section of the Supplemental Material, the quoted range of the number of pancakes is wrong. The number of pancakes is $2l + 1$, where l is in the range 8–16.

(5) In the “Interaction in the spin mixture” section of the Supplemental Material, we have taken the interaction energy per particle $E_{\text{int,mix}}$ to be $E_{\text{int}}/2$ for two spatially separated clouds. Here E_{int} is the interaction energy per particle for two completely overlapping atomic clouds. However, the interaction energy per particle scales as $N^{2/5}$ [4]. As a result, the interaction energy per particle is $E_{\text{int}}/2^{2/5} \approx 0.76E_{\text{int}}$ for two spatially nonoverlapping clouds. This marginally changes the lower bound of the theoretical estimation of the critical lattice depth for the density modulation and the upper bound for the spin mode in Fig. 4(a), leading to a marginally better fit to the data.

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