Comment on "Control of the Goos-Hänchen shift using a duplicated two-level atomic medium"

F. A. Hashmi*
Department of Physics, COMSATS Institute of Information Technology, Islamabad, Pakistan

M. A. Bouchene
Laboratoire de Collisions Agrégats Réactivité, C. N. R. S. UMR 5589, IRSAMC, Université Paul Sabatier, 118 Route de Narbonne, 31062 Toulouse CEDEX 4, France

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The recent paper by Ziauddin and Qamar [Phys. Rev. A **85**, 055804 (2012)] proposes control of the Goos-Hänchen shift of a Gaussian field incident on a cavity containing duplicated two-level atoms. This control relies on phase control of the optical response of the intracavity medium that has been demonstrated earlier [Phys. Rev. Lett. **101**, 213601 (2008)]. We show that the authors make an incorrect use of the results of this latter paper.

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Recently, Ziauddin and Qamar [1] have presented theoretical results regarding the control of the Goos-Hänchen shift (GHS). They considered a Gaussian incident beam on a cavity filled with a duplicated two-level atomic system and considered the positive and negative Goos-Hänchen shifts on the reflected and transmitted light. They have also investigated the effects of the incident light width on GHS and on the distortion of the reflected and transmitted light. The authors claim that the control of GHS comes through the phase control of the optical response of the duplicated two-level atomic system [2]. However, in our opinion, this claim of the authors is not justified, and hence, their results are questionable. We present our arguments in the following.

The key element in Ref. [1] is Eq. (3) taken from [2]

$$\chi = \frac{-2\alpha\Gamma_d}{k(\Delta + i\Gamma_d)} e^{2i\phi}, \tag{1}$$

where α is the field absorption coefficient defined at resonant frequency, Γ_d is the coherence relaxation rate, k is the wave number at resonance, and Δ is detuning. The phase ϕ in this expression is the relative phase between two fields that have orthogonal polarizations, parallel wave vectors, and the same frequency. This expression (1) gives the effective susceptibility for a weak σ-polarized probe field acting on $F_{1/2} \to F_{1/2}$ transition in the presence of a much stronger π-polarized control field. The important assumption in the validity of Eq. (1) is that the two fields must have parallel wave vectors with only a relative phase difference ϕ. If the two fields have a wave-vector mismatch, then the relative phase between the two becomes a space-dependent function. In this latter case, the response of the medium for the probe is similar to electromagnetic induced transparency [3,4]. It is to be noted here that Eq. (1) is not the susceptibility of the duplicated two-level system for any arbitrary field incident on the system.

In the concerned paper [1], the authors introduce a field whose expression is given by

$$E_x^i(z,y) = \frac{1}{\sqrt{2\pi}} \int E(k_y) e^{i(k_z z + k_y y)} dk_y, \tag{2}$$

where $E(k_y)$ is a Gaussian centered at k_{y0}. It is clear that the phase appearing in Eq. (1) and in Fig. 3 of the paper [1] cannot be defined for this field having a spread of wave vectors. Hence, their use of Eq. (1) for the calculation of the Goos-Hänchen shift for the field in Eq. (2) is not justified. Indeed, the authors first have to establish that different spectral components of the field in Eq. (2) experience a phase-dependent response from the medium and recalculate the correct optical reflection and transmission coefficients. Second, they have to show quantitatively that this phase-dependent control survives when it is averaged or is integrated over all spectral components of the field. Only after this can they claim the phase control of the Goos-Hänchen shift. Without this justification, their claims are unjustified, and their results are questionable.

*faheel4@comsats.edu.pk

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