Erratum: Optical activity of noncentrosymmetric metals [Phys. Rev. B 81, 094525 (2010)]

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The boundary condition for the combinations $E^{\pm} = E_x \pm iE_y$ of the electric-field component given by Eq. (75) in the original paper should be

$$\left(N^{\pm} \mp \frac{2\pi i\Lambda}{c}\right)E_0^{\pm} - E_1^{\pm} + E_2^{\pm} = 0. \tag{1}$$

The sign in the parentheses in this equation is $\mp$, as opposed to the sign $\pm$ in the original paper. The incorrect sign originated from an arithmetic error in the transition from Eq. (74) to Eq. (75) in the original paper. Here, E_1 and E_2 correspondingly are the complex amplitudes of the electric component of a wave normally incident and reflected from the surface of noncentrosymmetric media, and E_0 is the amplitude of the transmitted wave. $N^{\pm} = N \pm \frac{2\pi i\lambda}{c}$ is the refractive index of gyrotropic media. The second boundary condition is given by Eq. (69),

$$E_0^{\pm} = E_1^{\pm} + E_2^{\pm}. \tag{2}$$

The solution of these two equations yields the reflection coefficients for the clockwise and counterclockwise circular light polarization,

$$R^{\pm} = \frac{E_2^{\pm}}{E_1^{\pm}} = \frac{1-N}{1+N}. \tag{3}$$

Thus, unlike the statement formulated in the original paper, R^+ is proved to be equal to R^-. Hence, the Kerr effect for the rotation of the polarization of light reflected from the naturally gyrotropic media found in the original paper and Ref. [1] is in fact absent.

In microscopic calculations of the Kerr rotation undertaken in Refs. [2–4], the phenomenological expression for the Kerr angle was used, as obtained by Bungay, Swirko, and Zheludev [5]. These authors have derived boundary conditions for the electric field by making use of the textbook procedure, and the expression for the gyrotropy current given by Eq. (30) in Ref. [5], using our notation, appears as follows:

$$\mathbf{j}_g = \mathrm{rot}\,\lambda\mathbf{E}. \tag{4}$$

In fact, the correct gyrotropy current expression can be obtained from the gyrotropy term in action:

$$-\frac{1}{2c}\int dt d^3\mathbf{r}(\lambda\mathbf{E})\mathbf{B}. \tag{5}$$

By variation of action with respect to$-\mathbf{A}/c$ and making use of the definitions $\mathbf{E} = -(1/c)\partial\mathbf{A}/\partial t$ and $\mathbf{B} = \mathrm{rot}\,\mathbf{A}$, we arrive to

$$\mathbf{j}_g = \mathrm{rot}\,\lambda\mathbf{E} - \tfrac{1}{2}\nabla\lambda \times \mathbf{E}. \tag{6}$$

Here, unlike in the original paper, we have taken into account the coordinate dependence of the λ term,

$$\lambda(z) = \lambda\theta(z),$$

corresponding to half a space ($z > 0$) filled by gyrotropic media. The standard derivation making use of the Maxwell equations and the gyrotropy current (6) leads to the boundary conditions (1) and, hence, to the absence of the Kerr effect. It is worth noting that formula (1) in the original paper has been derived in a different way by not using formula (6) for the gyrotropy current, but by using the expression for the gyrotropy magnetic moment,

$$\mathbf{M}_g = \frac{1}{2c}\lambda\mathbf{E}, \tag{7}$$

which was also obtained from the gyrotropy action Eq. (5). Thus, now both derivations of the boundary conditions (1) yield the same result, leading to the absence of the Kerr rotation at light reflection from media with broken space inversion. On the contrary, the Kerr effect arises at reflection from media with broken time inversion. So, more efforts must be undertaken to explain the Kerr effect observation in high-T_c cuprates (see numerous references and discussion in Ref. [2]).

In conclusion, we stress that the main result of the original paper and Ref. [1] is the frequency-dependent gyrotropy current in an isotropic metal without space parity. To summarize, this Erratum is related to the Kerr effect that follows from (i) boundary conditions and (ii) gyrotropy current. In the derivation of the boundary conditions in the original paper there was an arithmetic error. As a result, the Kerr effect is absent but the current expression is correct and can be useful for future investigations.

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