Acoustic polarization singularities arising under torsion and orbital angular momentum exchange at the backward collinear acousto-optic diffraction: a case of crystals with point symmetry 3m. Errata

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Abstract. We introduce corrections to our recent article [1] (Mys O. et al., 2022. Ukr. J. Phys. Opt. 23: 107–115). The reasons of these corrections are (i) introduction of corrected values of the piezo-acoustic tensor components and (ii) consistent accounting for the fact that the optical beam appearing in the crystals with torsion-induced topological defects of optical-indicatrix orientation has a vector character whenever the incident beam is linearly polarized.

Keywords: polarization singularities, acoustic waves, orbital angular momentum, collinear acousto-optic diffraction

UDC: 535.42+534.2

We have found errors in our recent work [1]. Correction of these errors includes the following changes that must be introduced in its text, formulae and figures.

1. Abstract. Instead of the sentence

"It is also shown that a backward collinear acousto-optic (AO) interaction of a linearly polarized incident optical wave with a torsion-induced acoustic vortex wave is accompanied by a transfer of orbital angular momentum from the acoustic wave to the diffracted optical wave."

it should be

"It is shown that a vector beam with unit polarization order is generated in the crystals whenever the incident optical beam is polarized linearly. AO interaction of this vector beam with the acoustic beam bearing a singly charged vortex results in the diffracted optical wave which bears a vortex. The strength of embedded topological defect of the phase front of this vortex is determined by the sum of strengths of the topological defects referred to the incident optical wave and the acoustic wave. The diffracted optical beam represents a vortex beam with the orbital angular momentum $2\hbar$."

2. Page 109. Instead of the sentences

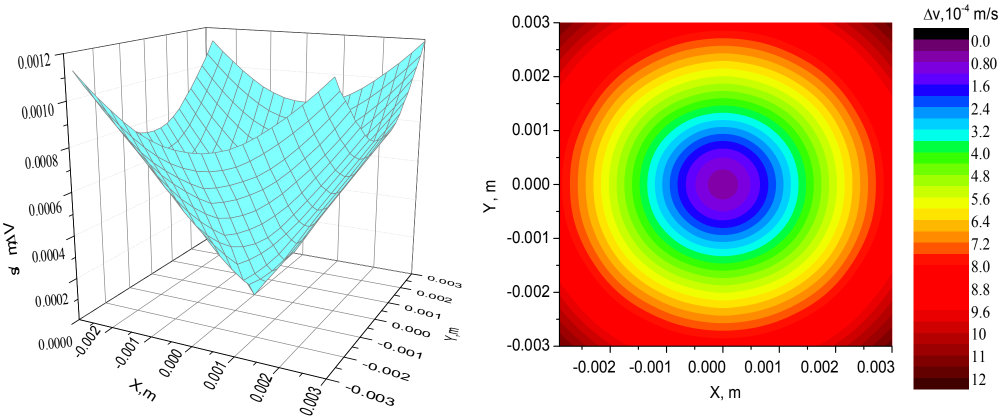
"Note that the changes in the AW velocities induced by the stresses 10^7 N/m^2 are usually small enough (e.g., a few m/s [11]).

The numerical values of the Θ_{ijklrt} components for LiNbO$_3$ are not available in the literature. In our simulations, we have taken the θ_{ijklmn} values which follow from the assumption that the coefficients C_{ijkl} and θ_{ijklmn} have the same order of magnitude [22]. As a result, we have obtained $\Theta_{444} = 0.01$, $\Theta_{344} = 0.03$, $\Theta_{114} = 0.08$, $\Theta_{244} = 0.02$, $\Theta_{144} = 0.04$, $\Theta_{124} = 0.06$ and $\Theta_{134} = 0.07$."

it should be
“Note that the changes in the AW velocities induced by the stress 10^6 N/m^2 are usually small enough (e.g., ~ 10 m/s [21]).

The numerical values of the Θ_{ijklrt} components for LiNbO$_3$ are not available in the literature. In our simulations, we have taken the Θ_{ijklrt} values, which follow from the experimental changes in the AW velocities known for the rocks [21]. As a result, we have obtained $\Theta_{444} = 100$, $\Theta_{344} = 300$, $\Theta_{114} = 800$, $\Theta_{244} = 200$, $\Theta_{144} = 400$, $\Theta_{124} = 600$ and $\Theta_{134} = 700$.”

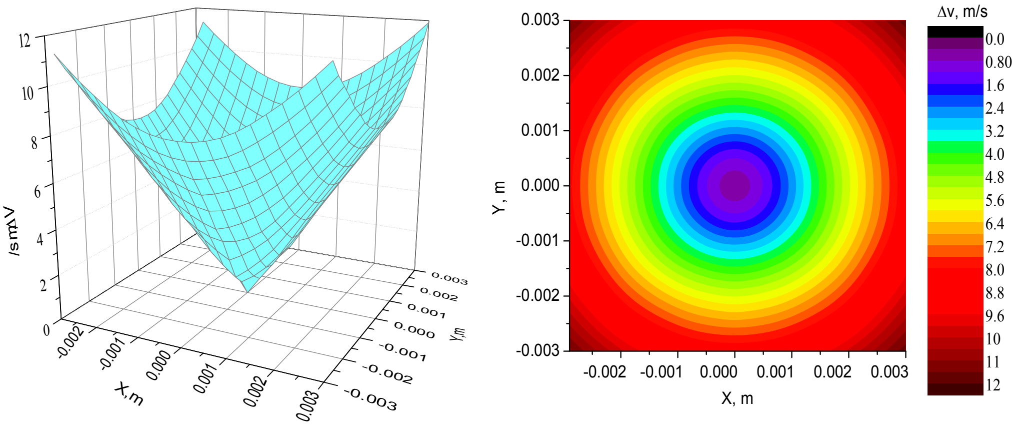
3. Instead of Fig. 1,



(a) (b)

Fig. 1. Elliptical-conical coordinate dependence of a torsion-induced difference of transverse AW velocities (a) and projection of this dependence in the *XY* plane (b). The torsion moment is equal to M_Z = 0.06 N×m.

it should be



(a) (b)

Fig. 1. Elliptical-conical coordinate dependence of a torsion-induced difference of transverse AW velocities (a) and projection of this dependence on the *XY* plane (b). The torsion moment is equal to M_Z = 0.06 N×m.

4. Pages 111 and 112. Instead of the sentences and equations
“Then the electric field components of the diffracted wave can be written as:

$$E_1^d = \Delta B_{11} D_1^{in} = p_{14} e_4 D_1^{in} , \tag{14}$$

or

$$E_2^d = \Delta B_{22} D_2^{in} = -p_{14} e_4 D_2^{in}, \tag{15}$$

where $D_1^{in} = D_0 e^{i(\omega t + k^{in} Z)}$ and $D_2^{in} = D_0 e^{i(\omega t + k^{in} Z)}$ are the electrical inductions of the incident optical waves with the unit amplitude D_0, which are polarized respectively parallel to the X and Y axes, p_{14} is the elasto-optic coefficient, ω the frequency of the incident optical wave, and t the time coordinate. Eqs. (14) and (15) can be rewritten as

$$E_1^d = \Delta B_{11} D_1^{in} = -p_{14} K_{ac} \sin \frac{\Delta\Gamma_{ac}(\rho, M_z)}{2} e^{i([\omega+\Omega]t - [k^{in} - K_{ac} Z]) + i2q\varphi}, \tag{16}$$

or

$$E_2^d = \Delta B_{22} D_2^{in} = p_{14} K_{ac} \sin \frac{\Delta\Gamma_{ac}(\rho, M_z)}{2} e^{i([\omega+\Omega]t - [k^{in} - K_{ac} Z]) + i2q\varphi}. \tag{17}$$

It is evident that the electric field of the diffracted optical wave involves the factor $e^{i2q\varphi}$. Hence, the diffracted beam contains a vortex with the charge $l = 2q = 1$ and, moreover, the OAM is being transferred from the AW to the diffracted optical wave."
it should be
"The linearly polarized incident optical waves with the polarizations parallel to the X (or Y) axis are described by the state vectors

$$D_1^{in} = D_o \begin{pmatrix} 1 \\ 0 \end{pmatrix} e^{i(\omega t + k^{in} Z)} \text{ or } D_2^{in} = D_o \begin{pmatrix} 0 \\ 1 \end{pmatrix} e^{i(\omega t + k^{in} Z)}. \tag{14}$$

Due to the torsion-induced singularity and according to the relation for the Jones matrix [25] we obtain

$$M(X,Y) = \cos \frac{\Delta\Gamma_{op}(\rho, M_z)}{2} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} + i \sin \frac{\Delta\Gamma_{op}(\rho, M_z)}{2} \begin{bmatrix} \cos 2\zeta_Z^{op} & \sin 2\zeta_Z^{op} \\ \sin 2\zeta_Z^{op} & -\cos 2\zeta_Z^{op} \end{bmatrix}, \tag{15}$$

where $\Delta\Gamma_{op}(\rho, M_z) = 2\pi \Delta n(\rho, M_z) d / \lambda$ is the torsion-induced optical phase difference, D_0 the unit electric-induction amplitude, and $\zeta_Z^{op} = \varphi / 2$ the torsion-induced optical-indicatrix rotation angle which is counted around the Z axis [6]. In other words, we have the topological defect of optical-indicatrix orientation with the strength equal to 1/2. The X- and Y-polarized incident optical waves are decomposed inside the crystal respectively as

$$D(X,Y) = D_0 \cos \frac{\Delta\Gamma_{op}(\rho, M_z)}{2} \begin{bmatrix} 1 \\ 0 \end{bmatrix} e^{i(\omega t + k^{in} Z)} + iD_0 \sin \frac{\Delta\Gamma_{op}(\rho, M_z)}{2} \begin{bmatrix} \cos 2\zeta_Z^{op} \\ \sin 2\zeta_Z^{op} \end{bmatrix} e^{i(\omega t + k^{in} Z)},$$

and (16)

$$D(X,Y) = D_0 \cos \frac{\Delta\Gamma_{op}(r, P_1)}{2} \begin{bmatrix} 0 \\ 1 \end{bmatrix} e^{i(\omega t + k^{in} Z)} + iD_0 \sin \frac{\Delta\Gamma_{op}(r, P_1)}{2} \begin{bmatrix} \sin 2\zeta_Z^{op} \\ -\cos 2\zeta_Z^{op} \end{bmatrix} e^{i(\omega t + k^{in} Z)}.$$

In fact, these relations contain the two terms. The first describes the wave with the incident polarization and the second one implies the optical vector beam with the unit polarization order.

For the case of X- and Y-polarized incident optical waves, the electric-field components of the diffracted wave can be written respectively as

$$E^d = -ip_{14}\sin\frac{\Delta\Gamma_{op}(\rho,M_z)}{2}\sin\frac{\Delta\Gamma_{ac}(\rho,M_z)}{2}\begin{bmatrix}1\\ i\end{bmatrix}e^{i\left[2q\varphi+2\zeta_Z^{op}+[\omega+\Omega]t+[k^{in}-K_{ac}Z]\right]},$$

and (17)

$$E^d = -p_{14}\sin\frac{\Delta\Gamma_{op}(\rho,M_z)}{2}\sin\frac{\Delta\Gamma_{ac}(\rho,M_z)}{2}\begin{bmatrix}1\\ i\end{bmatrix}e^{i\left[2q\varphi+2\zeta_Z^{op}+[\omega+\Omega]t+[k^{in}-K_{ac}Z]\right]}.$$

Here p_{14} denotes the elasto-optic coefficient. Note that D_0, e_0 and the corresponding unit parameter referred to K_{ac} are not written down in these equations for the reasons of brevity. One can see that the both diffracted optical waves are RH circularly polarized. They contain a topological defect of the phase front. The strength of the latter is equal to the sum of strengths of the defects of optical and acoustic waves: $q^d = \frac{1}{2}\left(2q\varphi + 2\zeta_Z^{op}\right) = 1$. Hence, the diffracted wave bears a doubly charged optical vortex with the OAM equal to $2\hbar$."

5. Conclusion. Instead of the sentence

"We have also shown that the process of backward collinear AO interaction of the linearly polarized incident optical wave with the torsion-induced acoustic vortex wave is accompanied by a transfer of OAM from the AW to the diffracted optical wave."

it should be

"We have shown that, in the case of linearly polarized incident optical wave, a vector beam with the unit polarization order is generated in the crystals. The AO interaction of this vector beam with the acoustic beam bearing a singly charged vortex results in vortex-bearing diffracted optical wave. The strength of embedded topological defect of the phase front of this wave is the sum of strengths of the topological defects referred to the incident optical wave and the AW. The diffracted optical beam represents an anisotropic vortex beam with the OAM equal to $2\hbar$."

6. Анотація. Instead of the sentence

"Також показано, що зворотна колінеарна акустооптична (АО) взаємодія лінійно поляризованої падаючої оптичної хвилі з акустичною вихровою хвилею, індукованою крученням, супроводжується передаванням орбітального кутового моменту від акустичної хвилі до дифрагованої оптичної хвилі."

it should be

"Показано, що у разі лінійно поляризованої падаючої оптичної хвилі в кристалах генерується векторний пучок з одиничним порядком поляризації. Акустооптична (АО) взаємодія цього векторного пучка з акустичним променем, який несе однозарядний вихор, приводить до дифрагованої оптичної хвилі, яка несе вихор із вбудованим топологічним дефектом фазового фронту. Сила останнього визначається сумою сил топологічних дефектів падаючої оптичної та акустичної хвиль. Дифрагований оптичний промінь – це вихровий промінь із орбітальним моментом імпульсу, який дорівнює $2\hbar$."

References

1. Mys O., Kostyrko M., Adamenko D., Skab I. and Vlokh R. 2022. Acoustic polarization singularities arising under torsion and orbital angular momentum exchange at the backward collinear acousto-optic diffraction: a case of crystals with point symmetry 3m. Ukr. J. Phys. Opt. **23**: 107–115.

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Анотація. *Ми внесли поправки до нашої нещодавньої статті [1] (Mys O. et al., 2022. Ukr. J. Phys. Opt.* ***23****: 107–115). Причинами цих поправок є (1) введення коректніших величин компонент п'єзоакустичного тензора та (2) послідовне врахування того факту, що оптичний промінь, який з'являється в кристалах з індукованими крученням топологічними дефектами орієнтації оптичної індикатриси, має векторний характер, якщо падаючий промінь поляризований лінійно.*