Symmetry analysis of the photorefractive electrogyration and electrogyration study in the $LiNbO_3$ crystals

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Abstract

The article is devoted to the phenomenological investigation of the possibility of the optical activity appearing under the photorefractive effect in the non-gyrotropic crystals. On the base of the symmetry analysis it is shown that in the crystals that belong to the planar and axially-inversion point groups of the symmetry ($\bar{4}3m$, $\bar{6}m2$, $\bar{6}$, 3m, 6mm, 4mm) optical activity can be induced by the electrogyration effect caused by the photorefractivity. In the crystals that belong to the point group of symmetry 6mm, 4mm, 3m, $\bar{6}$, $\bar{6}m2$ optical activity can be induced by photovoltaic and linear electrogyration effects while in the crystals that belong to the $\bar{4}3m$ group of the symmetry - by photovoltaic and quadratic electrogyration effects. The electrogyration effect in the $LiNbO_3$ crystal was experimentally investigated. The component of electrogyration tensor was determined as $\gamma_{41}=(3.39\pm1.3)\times10^{-12}$m/V and electrogyration diffraction effectivity was calculated: η=1.5%. It was shown that the diffraction of light on the electrogyration photorefractive grating should be only anisotropical.

Key words: electrogyration, photorefraction effect, optical activity.

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Introduction

The photorefractive effect can appear in the crystals as a result of the photovoltaic and electrooptical effects. The space charges electric field induced by electric field of the optical radiation through the photovoltaic effect caused the change of refractive indexes by the Pockels effect. But in the general case space charges electric field (E^{sc}_m, E^{sc}_n) that appear in the result of the charges distribution can change not only the real part of the dielectric permitivity (refractive indexes) but also the imaginary part (gyration) [1]:

$$\varepsilon_{ij}=\varepsilon_{ij}^{o}+ie_{ijl}g_{lk}k_k, \qquad (1)$$

$$\Delta\varepsilon_{ij}^{o}=r_{ijm}E^{sc}_m+R_{ijmn}E^{sc}_mE^{sc}_n, \qquad (2)$$

$$\Delta g_{lk}=\gamma_{lkm}E^{sc}_m+\delta_{lkmn}E^{sc}_mE^{sc}_n, \qquad (3)$$

where r_{ijm}, R_{ijmn} - coefficients of the Pockels and Kerr effect and γ_{lkm}, δ_{lkmn} - third and fourth rank axial tensors of the linear and quadratic electrogyration effect, respectively. It is known that due to the symmetry of the gyration tensor (second rank axial tensor g_{lk}) optical activity can exist only in the non-centrosymmetrical crystals as well as photovoltaic effect which is described by the polar third rank tensor ($j_n=\beta_{nrt}E_nE_t$, where j_n is the vector of the bulk photovoltaic current that is parallel to the vector of the space charge electric field E^{sc}). So, one can suppose that photorefractive electrogyration effect can appear only in the crystals that already possess optical activity. The present paper is devoted to analyzing the conditions in which optical activity can appear in the non-gyrotropic crystalsunder the photorefractivity and experimental studying of the electrogyration in the $LiNbO_3$ crystals.

Symmetry analysis

Linear electrogyration can exist in the non–centrosymmetrical as well as in the centrosymmetrical medium, except crystals which belong to the m3m and $\bar{4}3m$ point group of the symmetry. The effect of the change of the optical activity under the photorefractive effect in the crystals that already possess gyration have been already studed yet [2-4]. From other side in the crystals that belong to the planar and axially-inversion point groups of the symmetry ($\bar{4}3m$, $\bar{6}m2$, $\bar{6}$, 3m, 6mm, 4mm) optical activity could be induced by the electrogyration effect caused by the photorefractivity and in these crystals photovoltaic effect could also exist. The appearance of the optical activity in these crystals is connected with the local lowering of the symmetry under the space charge electric field induced by the photovoltaic effect. In the cubic crystals with the symmetry $\bar{4}3m$ optical activity can be induced only by the quadratic electrogyration. Let us consider the possibility of the appearing of the photorefractive electrogyration effect in these crystals in the case when optical radiation is propagated along the principle cystallophysical axis. The results of this analyzing are collected in the Table1. It is necessary to note, that the well known photorefractive $LiNbO_3$ crystals belong to the point group of the symmetry 3m.

Table 1

Symmetry of the crystals	Components of the wave vector and the light polarization	Change of the symmetry under the space charges electric field	Components of the photovoltaic current	Equations for the gyration tensor
1	2	3	4	5
6mm, 4mm	k_1, E_2E_2	non change	$j_3=\beta_{13}E_2E_2$	$g_{ij}=0$
	k_1, E_3E_3	non change	$j_3=\beta_{33}E_3E_3$	$g_{ij}=0$
	k_1, E_2E_3	6mm → m 4mm → m	$j_3=\beta_{13}E_2E_2+\beta_{33}E_3E_3$ $j_2=\beta_{42}E_2E_3$	$g_{31}=-\gamma_{41}E^{sc}_2$ $g_{12}=\delta_{16}E^{sc2}_2$
	k_2, E_1E_1	non change	$j_3=\beta_{13}E_1E_1$	$g_{ij}=0$
	k_2, E_3E_3	non change	$j_3=\beta_{33}E_3E_3$	$g_{ij}=0$
	k_2, E_3E_1	6mm → m 4mm → m	$j_1=\beta_{42}E_3E_1$ $j_3=\beta_{13}E_1E_1+\beta_{33}E_3E_3$	$g_{32}=\gamma_{41}E^{sc}_1$ $g_{12}=-\delta_{16}E^{sc2}_1$
	k_3, E_1E_1	non change	$j_3=\beta_{13}E_1E_1$	$g_{ij}=0$
	k_3, E_2E_2	non change	$j_3=\beta_{13}E_2E_2$	$g_{ij}=0$
	k_3, E_1E_2	non change	$j_3=\beta_{13}E_1E_1+\beta_{13}E_2E_2$	$g_{ij}=0$
3m	k_1, E_2E_2	3m → m	$j_2=\beta_{12}E_2E_2$ $j_3=\beta_{13}E_2E_2$	$g_{31}=-\gamma_{41}E^{sc}_2-\delta_{46}E^{sc2}_2$ $g_{12}=-\gamma_{11}E^{sc}_2+\delta_{61}E^{sc2}_2$
	k_1, E_3E_3	non change	$j_3=\beta_{33}E_3E_3$	$g_{ij}=0$
	k_1, E_2E_3	3m → m	$j_2=\beta_{42}E_2E_3+\beta_{12}E_2E_2$ $j_3=\beta_{33}E_3E_3+\beta_{13}E_2E_2$	$g_{31}=-\gamma_{41}E^{sc}_2-\delta_{46}E^{sc2}_2$ $g_{12}=-\gamma_{11}E^{sc}_2+\delta_{61}E^{sc2}_2$
	k_2, E_1E_1	3m → m	$j_2=-\beta_{12}E_1E_1$ $j_3=\beta_{13}E_1E_1$	$g_{31}=-\gamma_{41}E^{sc}_2-\delta_{46}E^{sc2}_2$ $g_{12}=-\gamma_{11}E^{sc}_2+\delta_{61}E^{sc2}_2$
	k_2, E_3E_3	non change	$j_3=\beta_{33}E_3E_3$	$g_{ij}=0$

1	2	3	4	5
3m	k_2, E_3E_1	3m → 1	$j_1=\beta_{42}E_1E_3$ $j_2=-\beta_{12}E_1E_1$ $j_3=\beta_{13}E_1E_1+\beta_{33}E_3E_3$	$g_{11}=\gamma_{11}E^{sc}_1$ $g_{22}=-\gamma_{11}E^{sc}_1=-g_{11}$ $g_{23}=\gamma_{41}E^{sc}_1$ $g_{13}=-\gamma_{41}E^{sc}_2-\delta_{46}E^{sc2}_2+\delta_{46}E^{sc2}_1$ $g_{12}=-\gamma_{11}E^{sc}_2-\delta_{61}E^{sc2}_1+\delta_{61}E^{sc2}_2$
	k_3, E_1E_1	3m → m	$j_2=-\beta_{12}E_1E_1$ $j_3=\beta_{13}E_1E_1$	$g_{31}=-\gamma_{41}E^{sc}_2-\delta_{46}E^{sc2}_2$ $g_{12}=-\gamma_{11}E^{sc}_2+\delta_{61}E^{sc2}_2$
	k_3, E_2E_2	3m → m	$j_2=\beta_{12}E_2E_2$ $j_3=\beta_{13}E_2E_2$	$g_{31}=-\gamma_{41}E^{sc}_2-\delta_{46}E^{sc2}_2$ $g_{12}=-\gamma_{11}E^{sc}_2+\delta_{61}E^{sc2}_2$
	k_3, E_1E_2	3m → 1	$j_1=\beta_{12}E_1E_2$ $j_2=-\beta_{12}E_1E_1+\beta_{12}E_2E_2$ $j_3=\beta_{13}E_1E_1+\beta_{13}E_2E_2$	$g_{11}=\gamma_{11}E^{sc}_1$ $g_{22}=-\gamma_{11}E^{sc}_1=-g_{11}$ $g_{23}=\gamma_{41}E^{sc}_1$ $g_{13}=-\gamma_{41}E^{sc}_2-\delta_{46}E^{sc2}_2+\delta_{46}E^{sc2}_1$ $g_{12}=-\gamma_{11}E^{sc}_2-\delta_{61}E^{sc2}_1+\delta_{61}E^{sc2}_2$
$\bar{6}$	k_1, E_2E_2	$\bar{6}$ → m	$j_1=-\beta_{11}E_2E_2$ $j_2=\beta_{12}E_2E_2$	$g_{23}=\gamma_{41}E^{sc}_1+\gamma_{42}E^{sc}_2+\delta_{41}E^{sc2}_1-\delta_{42}E^{sc2}_2$ $g_{13}=\gamma_{42}E^{sc}_1-\gamma_{41}E^{sc}_2+\delta_{46}E^{sc2}_1+\delta_{46}E^{sc2}_2$
	k_1, E_3E_3	non change	$j_i=0$	$g_{ij}=0$
	k_1, E_2E_3	$\bar{6}$ → m	$j_1=-\beta_{11}E_2E_2$ $j_2=\beta_{12}E_2E_2$	$g_{23}=\gamma_{41}E^{sc}_1+\gamma_{42}E^{sc}_2+\delta_{41}E^{sc2}_1-\delta_{42}E^{sc2}_2$ $g_{13}=\gamma_{42}E^{sc}_1-\gamma_{41}E^{sc}_2+\delta_{46}E^{sc2}_1+\delta_{46}E^{sc2}_2$
	k_2, E_1E_1	$\bar{6}$ → m	$j_1=\beta_{11}E_1E_1$ $j_2=-\beta_{12}E_1E_1$	$g_{23}=\gamma_{41}E^{sc}_1+\gamma_{42}E^{sc}_2+\delta_{41}E^{sc2}_1-\delta_{42}E^{sc2}_2$ $g_{13}=\gamma_{42}E^{sc}_1-\gamma_{41}E^{sc}_2+\delta_{46}E^{sc2}_1+\delta_{46}E^{sc2}_2$
	k_2, E_3E_3	non change	$j_i=0$	$g_{ij}=0$
	k_2, E_1E_3	$\bar{6}$ → m	$j_1=\beta_{11}E_1E_1$ $j_2=-\beta_{12}E_1E_1$	$g_{23}=\gamma_{41}E^{sc}_1+\gamma_{42}E^{sc}_2+\delta_{41}E^{sc2}_1-\delta_{42}E^{sc2}_2$ $g_{13}=\gamma_{42}E^{sc}_1-\gamma_{41}E^{sc}_2+\delta_{46}E^{sc2}_1+\delta_{46}E^{sc2}_2$
	k_3, E_1E_1	$\bar{6}$ → m	$j_1=\beta_{11}E_1E_1$ $j_2=-\beta_{12}E_1E_1$	$g_{23}=\gamma_{41}E^{sc}_1+\gamma_{42}E^{sc}_2+\delta_{41}E^{sc2}_1-\delta_{42}E^{sc2}_2$ $g_{13}=\gamma_{42}E^{sc}_1-\gamma_{41}E^{sc}_2+\delta_{46}E^{sc2}_1+\delta_{46}E^{sc2}_2$
	k_3, E_2E_2	$\bar{6}$ → m	$j_1=-\beta_{11}E_2E_2$ $j_2=\beta_{12}E_2E_2$	$g_{23}=\gamma_{41}E^{sc}_1+\gamma_{42}E^{sc}_2+\delta_{41}E^{sc2}_1-\delta_{42}E^{sc2}_2$ $g_{13}=\gamma_{42}E^{sc}_1-\gamma_{41}E^{sc}_2+\delta_{46}E^{sc2}_1+\delta_{46}E^{sc2}_2$

1	2	3	4	5
$\bar{6}$	$k_3,\ E_1E_2$	$\bar{6} \rightarrow m$	$j_1=\beta_{11}E_1E_1-\beta_{11}E_2E_2-$ $-\beta_{12}E_1E_2$ $j_2=-\beta_{12}E_1E_2+\beta_{12}E_2E_2-$ $-\beta_{11}E_1E_2$	$g_{23}=\gamma_{41}E^{sc}_1+\gamma_{42}E^{sc}_2+\delta_{41}E^{sc2}_1-$ $\delta_{42}E^{sc2}_2$ $g_{13}=\gamma_{42}E^{sc}_1-$ $\gamma_{41}E^{sc}_2+\delta_{46}E^{sc2}_1+\delta_{46}E^{sc2}_2$
$\bar{6}m2$	$k_1,\ E_2E_2$	$\bar{6}m2 \rightarrow mm2$	$j_2=\beta_{12}E_2E_2$	$g_{31}=-\gamma_{41}E^{sc}_2-\delta_{46}E^{sc2}_2$
	$k_1,\ E_3E_3$	non change	$j_i=0$	$g_{ij}=0$
	$k_1,\ E_2E_3$	$\bar{6}m2 \rightarrow mm2$	$j_2=\beta_{12}E_2E_2$	$g_{31}=-\gamma_{41}E^{sc}_2-\delta_{46}E^{sc2}_2$
	$k_2,\ E_1E_1$	$\bar{6}m2 \rightarrow mm2$	$j_2=-\beta_{12}E_1E_1$	$g_{31}=-\gamma_{41}E^{sc}_2-\delta_{46}E^{sc2}_2$
	$k_2,\ E_3E_3$	non change	$j_i=0$	$g_{ij}=0$
	$k_2,\ E_1E_3$	$\bar{6}m2 \rightarrow mm2$	$j_2=-\beta_{12}E_1E_1$	$g_{31}=-\gamma_{41}E^{sc}_2-\delta_{46}E^{sc2}_2$
	$k_3,\ E_1E_1$	$\bar{6}m2 \rightarrow m$	$j_2=-\beta_{12}E_1E_1$	$g_{31}=-\gamma_{41}E^{sc}_2-\delta_{46}E^{sc2}_2$
	$k_3,\ E_2E_2$	$\bar{6}m2 \rightarrow m$	$j_2=\beta_{12}E_2E_2$	$g_{31}=-\gamma_{41}E^{sc}_2-\delta_{46}E^{sc2}_2$
	$k_3,\ E_1E_2$	$\bar{6}m2 \rightarrow m$	$j_1=-\beta_{12}E_1E_2$ $j_2=-\beta_{12}E_1E_1+\beta_{12}E_2E_2$	$g_{32}=\gamma_{41}E^{sc}_1$ $g_{31}=-\gamma_{41}E^{sc}_2+\delta_{46}E^{sc2}_1-\delta_{46}E^{sc2}_2$
$\bar{4}3m$	$k_1,\ E_2E_2$	non change	$j_i=0$	$g_{ij}=0$
	$k_1,\ E_3E_3$	non change	$j_i=0$	$g_{ij}=0$
	$k_1,\ E_2E_3$	$\bar{4}3m \rightarrow \bar{4}2m$	$j_1=\beta_{41}E_2E_3$	$g_{22}=-\delta_{12}E^{sc2}_1$ $g_{33}=\delta_{12}E^{sc2}_1$
	$k_2,\ E_1E_1$	non change	$j_i=0$	$g_{ij}=0$
	$k_2,\ E_3E_3$	non change	$j_i=0$	$g_{ij}=0$
	$k_2,\ E_1E_3$	$\bar{4}3m \rightarrow \bar{4}2m$	$j_2=\beta_{41}E_1E_3$	$g_{11}=\delta_{12}E^{sc2}_2$ $g_{33}=-\delta_{12}E^{sc2}_2$
	$k_3,\ E_1E_1$	non change	$j_i=0$	$g_{ij}=0$
	$k_3,\ E_2E_2$	non change	$j_i=0$	$g_{ij}=0$
	$k_3,\ E_1E_2$	$\bar{4}3m \rightarrow \bar{4}2m$	$j_3=\beta_{41}E_1E_2$	$g_{11}=-\delta_{12}E^{sc2}_3$ $g_{22}=\delta_{12}E^{sc2}_3$

Tensors β_{ijk}, δ_{ijkl} and γ_{ijk} sre presented in matrix form.

Experimental

For the calculation of the value of the photorefractive induced optical activity it is necessary to know the electrogyration coefficients in the chosen crystals. The one of the photorefractive crystals is well investigated lithium-niobate that belongs to the planar group of the symmetry 3m and does not possess optical activity. Unfortunately the electrogyration effect in these crystals is not studied yet. The reason of this fact, perhaps is connected with the difficulties of such experiment. Electrogyration should not appear in the crystals with the symmetry 3m if the electric field is applied along three-fold axis and optical radiation is propagated along optical axis. If the electric field is applied in the direction perpendicular to the three-fold axis optical birefringence will always appear in the Z - direction. It means that electrogyration effect should be investigated under conditions of the presence of the linear birefringence.

Let us consider the peculiarities of the electrooptical effect in the $LiNbO_3$ crystals in the case if the electric field is applied in the X and Y - directions. According to the Curie principle the application of the electric field along *Y* axis should cause the lowering of the symmetry 3m→m and along X- axis - 3m→1. The both groups of the symmetry (m and 1) permit existing of the optical activity and crystals that belong to this groups are optically biaxial. Under the electric field E_2 the $LiNbO_3$ crystals become optically biaxial and the optical axes will belong to the *ZY* or *ZX* planes, dependently of the sign of the field (Fig.1,a). At the same time gyration tensor should possess two non-zero components g_{13} and g_{23} (Fig.1,a). It means that optical activity can appear in the direction of the one of optical axes only in the case if optical axes plane will be perpendicular to the *YZ*–plane. The orientation of the optical axes plane depends on the sign of the E_2 field. Then if optical beam will propagate along one of the optical axis which belong to the *XZ*–plane one could observe the rotation of the polarization plane caused by the electrogyration effect. At the application of the E_1 electric field the crystal should become optically biaxial, optical indicatrix will turn around *Z* axis on the 45° and all components of the gyration tensor should be non-zero (Fig.1,b). In both cases it is possible to investigate the electrogyration effect under conditions when optical radiation will propagate along one of the optical axes by measuring of the rotation the polarization plane.

In our experiments lithium-niobate crystal was prepared with the faces perpendicular to the principle crystallophysical axis with the dimensions 10×10×10mm^3 and the face that is perpendicular to the *Z*-axis was polished by the diamond paste. Electrical voltage was applied along *X* and *Y* axes up to the 13kV. Sample with the electrical field application was placed on the optical micropozicioner with the angle scale, which could be turned around direction of the optical beam propagation (λ=632.8nm). The measurements of the electrogyration effect were held with the help of the Faraday cell at the room temperature (*T*=20°C). The polarization of the incident beam was parallel or perpendicular to the incident plane.

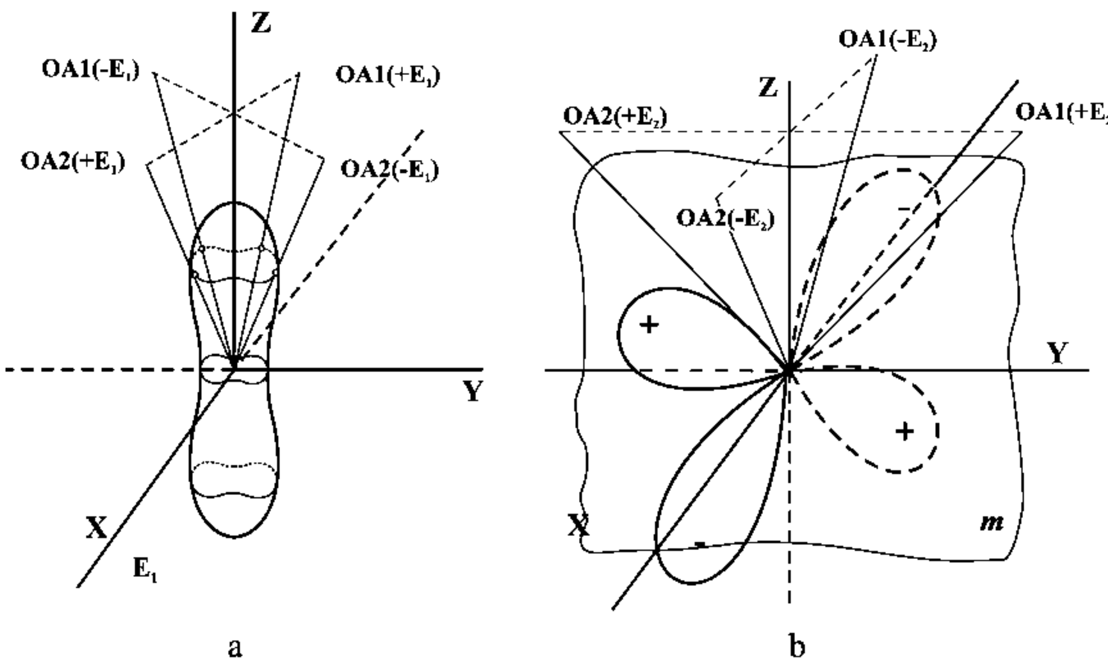

Fig.1.Gyration surfaces and optical axes in the $LiNbO_3$ crystals under the application of the electrical field a)E_2 and b)E_1.

Results and discussion

Let us consider the equation for the scalar gyration parameter at the application of the electric field along *X* and *Y* axis of the $LiNbO_3$ crystals. At the E_2 field the relation for the gyration can be written as:

$$G=g_{ij}\,l_i l_j=\rho\lambda n/\pi=2g_{12}l_1l_2+ +2g_{13}l_1l_3=-2\gamma_{11}E_2l_1l_2-2\gamma_{41}E_2l_1l_3, \quad (4)$$

where *G* - is scalar gyration parameter, g_{ij} - are components of the gyration tensor , *n* - is the refractive index in the direction of the optical axis, ρ - is the polarization plane rotary power, λ - is the wavelength of the optical radiation, γ_{ij} - are the components of the electrogyration tensor and l_i, l_j - are direction cosines of the wave vector. It is suitable to rewrite the equation (4) in the spherical coordinate:

$$G=g_{ij}\,l_il_j=\rho\lambda n/\pi=-\gamma_{41}E_2\sin2\theta \quad (5)$$

and

$$\gamma_{41}=-\rho\lambda n/\pi E_2\sin2\theta, \quad (6)$$

where θ - is the angle between the optical axis in the optically biaxial $LiNbO_3$ crystals and *Z* - axis. At the E_1 field the relation for the gyration can be written as:

$$G=g_{ij}\,l_il_j=\rho\lambda n/\pi=g_{11}l_1l_1+g_{22}l_2l_2+2g_{12}l_1l_2= =\gamma_{11}E_1l_1l_1-\gamma_{11}E_1l_2l_2+2\gamma_{41}E_1l_3l_2 \quad (7)$$

In the spherical coordinate (7) can be rewritten as

$$G=g_{ij}\,l_il_j=\rho\lambda n/\pi=(2)^{1/2}\gamma_{41}E_1\sin2\theta$$

and (8)

$$\gamma_{41}=\rho\lambda n/(2)^{1/2}\pi\gamma_{41}E_1\sin2\theta.$$

In the Fig.2 the dependence of the optical rotary power on the strength of electrical field E_2 is shown. According to the formula (6) the calculated value is $\gamma_{41}=(3.39\pm1.3)\times10^{-12}$m/V. In the case when electrical field E_2 leads to the splitting of optical axis in *YZ* plane the deviation of the rotation of polarization plane was in order of the experimental error. Taking into account the largest value of the space charge electrical field ($E_{sc}\sim10^7$V/m) induced by optical radiation through photorefractivity [5] one can estimate the amplitude of the photorefractive periodical distribution of the gyration tensor will be $\Delta g_{ij}=3.9\times10^{-5}$. In this case the diffraction effectivity can be written as [6]

$$\eta=\sin^2\left(\frac{\pi\Delta nd}{\lambda\cos\theta}\right) \quad (9)$$

where *d* - is the interaction length, θ - is the incident angle of regording beam. In the case of the electrooptical and electrogyration grating recording the amplitude of the birefringence can be written as

$$\Delta n=(\Delta n_l^2+\Delta n_c^2)^{1/2}, \quad (10)$$

where Δn - is the total birefringence, Δn_l - is the linear birefringence induced by the electro-optical effect and $\Delta n_c=\Delta g_{ij}/\bar{n}$ - is the circular birefringence induced by the electrogyration ($\bar{n}=(n_e+n_o)/2=2.2864+2.2025=2.2445$ - the average value of the refractive indexes (according to [7] for the wavelength 632.8nm)). So, photorefractive $\Delta n_c=1.76\times10^{-5}$.

One can note that the electrogyration kind of diffraction can be only anisotropic because

$$E^{\omega}_i=(\chi_{ij}+ie_{ijl}\,g_{lk}k_k)D^{\omega}_j, \quad (11)$$

(where P^{ω}_i is the polarization of diffracted wave and E^{ω}_j - electrical field of incident wave) and in Levi-Civit tensor - e_{ijl} all indexes should be different. It means that polarization of incident and diffracted light should be mutually perpendicular and electrogyration diffraction could be simply separated from electrooptical one. Though it is reasonable to consider only the diffraction efficiency η of the diffraction on the electrogyration photorefractive grating.

$$\eta=sin^2\left(\frac{\pi\Delta n_c d}{\lambda cos\theta}\right) \quad (12)$$

For the λ=632.8nm, *d*=1mm and $\theta\approx45^o$ [8] $\eta\approx1.5\times10^{-2}$ or 1.5%. Comparing with diffraction effectivity obtained on the electrooptical grating for example in [8] the electrogyration diffraction efectivity it is of order smaller than electro-optical.

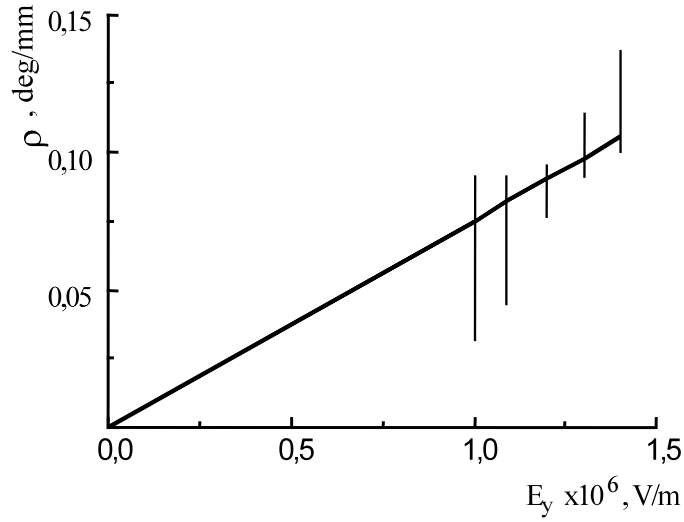

Fig.2.The dependence of the optical rotary power on the strength of electrical field E_2 in the $LiNbO_3$ crystals (λ=632.8nm).

Conclusions

1.The phenomenological investigation of the possibility of the optical activity appearing under the photorefraction effect in the non-gyrotropic crystals is made. On the base of the symmetry analysis it is shown that in the crystals that belong to the planar and axially-inversion point groups of the symmetry ($\bar{4}3m$, $\bar{6}m2$, $\bar{6}$, 3m, 6mm, 4mm) the optical activity could be induced by the electrogyration effect caused by the photorefractivity. In the crystals that belong to the point group of symmetry 6mm, 4mm, 3m, $\bar{6}$, $\bar{6}m2$ the optical activity could be induced by photovoltaic and linear electrogyration effects while in the crystals that belong to the $\bar{4}3m$ group of the symmetry - by photovoltaic and quadratic electrogyration effects.

2.The electrogyration effect in the $LiNbO_3$ crystal was experimentally investigated. The component of electrogyration tensor was determined as $\gamma_{41}=(3.39\pm1.3)\times10^{-12}$m/V and diffractive effectivity at the diffraction on the photorefractive electrogyration grating is estimated as η=1.5%. It was shown that diffraction of light on the electrogyration photorefractive grating should be only anisotropical.

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