# OPTICAL ELEMENTS BASED ON PHASE POLARIZATION GRATINGS

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We overview the main principles of polarization holography and concentrate the attention on thin phase holograms possessing exact half-wave birefringence plate properties. A method of phase control by optical elements with the spatially distributed axis of birefringence is analyzed. A "half-wave" polarization hologram can achieve the 100-% diffraction efficiency in a single diffracted order. The spatial orientation of the birefringence axis is determined for cylindrical and spherical optical focusing elements.

## 1. Introduction

Much attention is paid now to holographically generated phase polarization gratings [1, 2]. While the history of polarization holograms starts probably since the 1970s [3], now the subject is renewed with the opening of new recording techniques, materials, and important applications. Generally, the idea of the polarization holography is based on the main principle: a hologram registered in a polarization-sensitive material is able to restore the polarization state of the recording beams in the readout process.

At the first stages, the polarization holography was considered as an exotic version of the usual holography, due to the use of absorptive (dichroic) recording materials with, therefore, low diffraction efficiency. In the past decade, the situation changed radically owing to the beginning of liquid crystals (LC) exploitation for the formation of polarization elements. Successes in aligning the liquid crystal molecules along a predominant direction opened all advantages of polarization holography. In contrast to dichroic materials, LC are able to operate in the pure phase regime. Moreover, due to the high inherent birefringence, rather thin micrometer-thick LC films can perform the 100-% transformation of an input wave to the desired one in a single diffracted order. In this sense, LC-based polarization elements possess properties of amplitude sinusoidal diffraction gratings (absence of higher diffracted orders), Bragg holograms (diffraction efficiency close to 100%), and half-wave plates (polarization separation) [2].

A bright example of LC-based polarization elements for the phase control, namely the transformation of a plane wavefront to a helicoidal one inherent to an optical-vortex beam, was reported in [4]. The proposed optical element can be treated as a Gabor-type hologram which forms only one axial diffracted wave, in contrast to usual thin phase holograms.

The physical principle of the phase control has an analog with the Garetz effect [5], i.e. the dynamic variation of the phase of a circularly polarized wave transmitted through a rotating half-wave plate.

In the present work, we try to combine these independent ideas into one practical solution for the management of the transversal phase of an optical wave. First, we reproduce briefly the description of the basic principles of the recording and the readout of polarization gratings. Then, we will concentrate the attention on phase gratings, which are able, under certain conditions, to achieve a diffraction efficiency up to 100%. The spatial distribution of the birefringence axis orientation is determined for cylindrical and spherical focusing elements.

## 2. Polarization Gratings – General Approach

Figure 1 gives an example of the polarization field preparation for the grating recording. Two circularly polarized waves interfere at the angle $2\theta$ between them. Their amplitudes are supposed to be equal, but the signs of

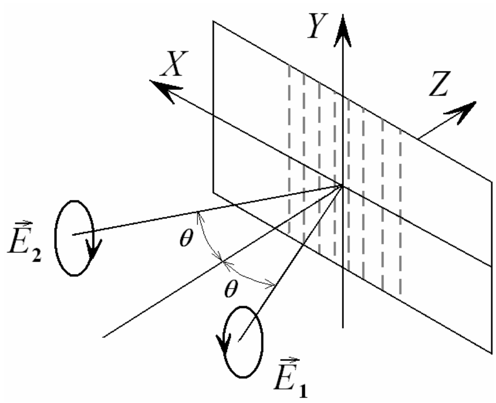


Fig. 1. Scheme of a polarization grating recording. Two waves with opposite circular polarizations and wave vectors **k** symmetrically oriented in the $XZ$ plane interfere at the $XY$ plane. Dashed lines show "fringes" of the equal polarization state

circular polarization are opposite. There is no intensity variation at the observation plane, but the polarization state of the interference field varies periodically along the $X$ axis. The analysis given below describes the polarization variation.

Two incident circularly polarized monochromatic waves shown in Fig. 1 can be written as

$$\mathbf{E}_1 = E_1(\hat{\mathbf{x}}\cos\theta + i\hat{\mathbf{y}} + \hat{\mathbf{z}}\sin\theta)\exp(ik_x x + ik_z z - i\omega t) \quad (1)$$

and

$$\mathbf{E}_2 = E_2(\hat{\mathbf{x}}\cos\theta - i\hat{\mathbf{y}} + \hat{\mathbf{z}}\sin\theta)\times$$

$$\times\exp(-ik_x x + ik_z z - i\omega t), \quad (2)$$

where $k_x^2 + k_z^2 = k^2$, $k = 2\pi/\lambda$ is the wave number ($\lambda$ is the wavelength), $\theta$ is the angle of incidence as shown in Fig. 1, and $\omega$ is the light frequency. First, we let the wave amplitudes to be equal: $E_1 = E_2 = E$.

The presence of the $z$-component of the field in Eqs. (1) and (2) is caused by the oblique incidence of the waves onto the observation plane. In the situation where the angle $\theta$ is small, these components are negligible. Then, the interference field, being a sum of the incident waves amplitudes, takes the form

$$\mathbf{E}_1 + \mathbf{E}_2 = 2E[\hat{\mathbf{x}}\cos\theta\cos(k_x x) + \hat{\mathbf{y}}\sin(k_x x) +$$

$$+\hat{\mathbf{z}}\sin\theta\cos(k_x x)]\exp(ik_z z - i\omega t). \quad (3)$$

According to Eq. (3), the field at any point of the $XY$ plane ($z$ = const) is linearly polarized with the components $E_x = E\cos\theta\cos(k_x x)$ and $E_y = E\sin(k_x x)$. The

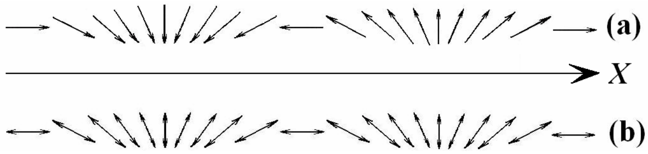


Fig. 2. Momentary distribution of the field in the interference pattern ($a$) and the steady polarization distribution along the $x$ axis ($b$). While one period is shown in ($a$), the polarization distribution attains two periods at the same distance ($b$)

Fig. 3. Calculated distribution of the polarization ellipse orientation in an interference field of two orthogonally circularly polarized plane waves with slightly different amplitudes $E_2/E_1 = 0.7$ (one spatial period is shown); with the axes of the elongated polarization ellipses being in the ratio $b/a = 0.176$

interference field possesses the periodicity along the $x$ axis with the period $2\pi/k_x$ (Fig. 2,$a$). Since the field oscillates with optical frequency $\omega$, the distribution of the polarization angle $\alpha(x)$ is as follows:

$$\tan\alpha = \left|\frac{E_y}{E_x}\right| = \frac{|\tan(k_x x)|}{\cos\theta}. \quad (4)$$

As seen, the period of a polarization distribution along the $x$ axis (Fig. 2,$b$) is $\Lambda = \pi/k_x$. With $k_x = k\sin\theta$, we have $\Lambda = \lambda/2\sin\theta$. Then, for small angles $\theta$, we can approximate $\alpha = k_x x$.

Of course, in the general situation, the writing wave amplitudes can differ from each other. Taking the inequality $E_1 \neq E_2$ into account, we can calculate the interference field similarly to Eq. (3). The resulting polarization distribution along the $X$ axis is shown in Fig. 3. At any point, the polarization is elliptic.

## 3. Polarization Grating Formation

Below, we assume the influence of the interference field on a recording material in the form of a thin film composed from anisotropic molecules which can be oriented along or normally to the light polarization. Figure 4 shows schematically the distribution of a field polarization in the observation plane $XY$ and a continuous line with the tangent coinciding with the field polarization. We name it the director line and accept that the molecules are oriented along the director line at any point.

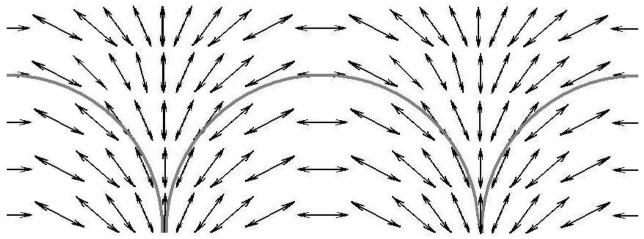

Fig. 4. Polarization distribution in the $XY$ plane shown by arrows and the director line shown as a continuous curve

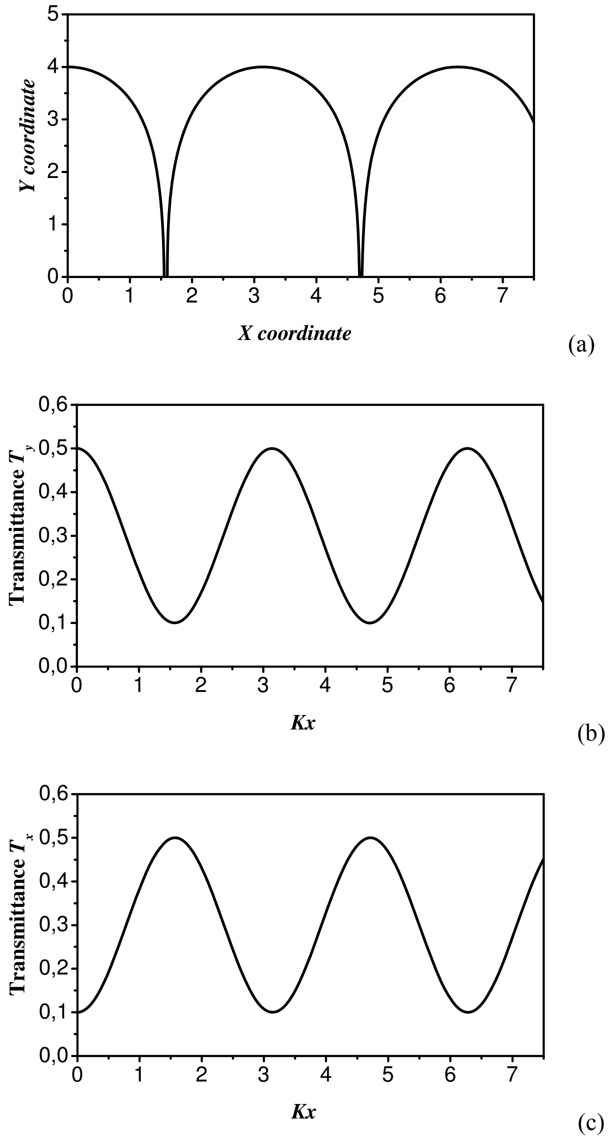


Fig. 5. ($a$) Calculated director line $F(x)$ and the amplitude transmittance of a polarization grating for incident $y$-polarized ($b$) and $x$-polarized waves ($c$)

To calculate the shape of the director line $F(x)$, we use the equation

$$\frac{dF(x)}{dx} = \tan\alpha, \tag{5}$$

where the inclination angle of the polarization plane $\alpha$ is determined by equality (4). The integration of the equation

$$\frac{dF(x)}{dx} = \frac{|\tan(k_x x)|}{\cos\theta} \tag{6}$$

gives the result

$$F(x) = \frac{\ln|\cos(k_x x)|}{\cos\theta} + C, \tag{7}$$

where the arbitrary constant $C$ corresponds to a parallel shift of the curve along $y$ axis. The shape of the calculated director line is shown in Fig. 5,$a$.

The molecules oriented along the line can possess anisotropic properties: dichroism, birefringence, or both in the general case. First, we consider amplitude-type gratings. The anisotropy accomplished with a periodic angular distribution of molecules results in the periodicity of the transmittance for an incident wave and, therefore, in a transmission grating origin. In the case of a $y$-polarized incident wave, the transmittance $T_y$ as a function of $x$ can be derived as

$$T_y(x) = \left[\exp(-\kappa_{\updownarrow} d)\cos(k_x x)\right]^2 + [\exp(-\kappa_{\leftrightarrow} d)\sin(k_x x)]^2, \tag{8}$$

where $\kappa_{\updownarrow}$ and $\kappa_{\leftrightarrow}$ are the absorption coefficients in parallel and perpendicularly to the molecular axis.

Equation (8) generates a harmonic transmission function

$$T_y(x) = \frac{\exp(-2\kappa_{\updownarrow} d) + \exp(-2\kappa_{\leftrightarrow} d)}{2} +$$

$$+ \frac{\exp(-2\kappa_{\updownarrow} d) - \exp(-2\kappa_{\leftrightarrow} d)}{2}\cos(2k_x x). \tag{9}$$

The calculated transmittance (amplitude) function $T_y(x)$ is shown schematically in Fig. 4,$b$. The transmission variation follows a harmonic rule (in the calculations, we took $\exp(-2\kappa_{\updownarrow} d) = 0.5$, $\exp(-2\kappa_{\leftrightarrow} d) = 0.1$, and $2k_x = K = 1$.

Similarly, the transmittance function for an $x$-polarized wave is

$$T_x(x) = \frac{\exp(-2\kappa_{\updownarrow} d) + \exp(-2\kappa_{\leftrightarrow} d)}{2} -$$

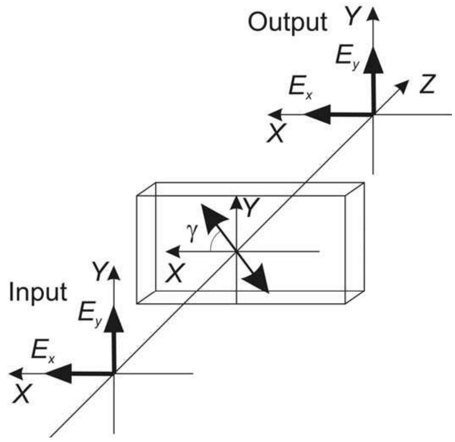


Fig. 6. Transformation of the input wave to the output wave by a birefringent plate. The input wave has field components $E_x$ and $E_y$ of monochromatic oscillations with a phase shift $\Phi$ between them

$$-\frac{\exp(-2\kappa_{\updownarrow}d)-\exp(-2\kappa_{\leftrightarrow}d)}{2}\cos(2k_x x). \tag{10}$$

The diffraction of a $y$-polarized plane wave by a thin grating with the transmittance function described by Eq. (9) results in the appearance of diffraction beams with amplitudes

$$E_d = E\frac{\exp(-2\kappa_{\updownarrow}d)-\exp(-2\kappa_{\leftrightarrow}d)}{4}, \tag{11}$$

and the zero-order (directly transmitted) wave with the amplitude

$$E_0 = E\frac{\exp(-2\kappa_{\updownarrow}d)+\exp(-2\kappa_{\leftrightarrow}d)}{2}. \tag{12}$$

For an $x$-polarized wave, the amplitudes of the diffracted waves are the same, the difference appears only in a $\pi$ phase shift.

Like an ordinary amplitude grating with pure harmonic modulation, high-order diffraction beams are absent. The highest achievable diffraction efficiency, as the ratio of intensities of a diffracted beam and the input beam, is $\eta = |E_d/E|^2 = 1/16$ (6.25%) in the limiting case where $\exp(-2\kappa_{\leftrightarrow}d) = 0$ and $\exp(-2\kappa_{\updownarrow}d) = 1$.

For an arbitrarily polarized input wave, the state of polarization in the ± first diffraction orders is circular, with opposite signs of the chirality.

## 4. Phase Polarization Gratings

In the case of the pure phase response, i.e. in the absence of the anisotropic absorption of a medium, the analysis can be performed within a scheme of the transformation of an input field polarization to the output beam polarization by an element with a 2D distribution of the birefringence axis. A brief sketch accompanied with Fig. 6 is given below. We assume a parallel slab with thickness $d$ and the optical axis oriented (locally) at the angle $\gamma$ to the $x$ axis. To describe the birefringence, a refractive index $n_{\updownarrow}$ is attributed to the polarization coinciding with the axis direction and a refractive index $n_{\leftrightarrow}$ for the orthogonal direction.

With the input field (normal incidence of a plane wave) possessing an arbitrary (elliptic in the general case) polarization

$$\mathbf{E}^{(\mathrm{in})} = \hat{x}E_x + \hat{y}E_y e^{i\Phi}, \tag{13}$$

where $E_x$ and $E_y$ are components of the field amplitude (projections onto the $x$ and $y$ axes, respectively), and $\Phi$ is the phase shift, the transformation of the polarization state by the anisotropic element results in the following form of the output field:

$$\mathbf{E}^{(\mathrm{out})} = \hat{x}E_x^{(\mathrm{out})} + \hat{y}E_y^{(\mathrm{out})}, \tag{14}$$

where

$$E_x^{(\mathrm{out})} = \left[E_x\left(\sin^2\gamma\, e^{-\frac{i\Delta nkd}{2}} + \cos^2\gamma\, e^{\frac{i\Delta nkd}{2}}\right) + \right.$$

$$\left. + E_y \sin\gamma\cos\gamma\, e^{i\Phi}\left(e^{-\frac{i\Delta nkd}{2}} - e^{\frac{i\Delta nkd}{2}}\right)\right]\times$$

$$\times\exp\left(i\frac{n_{\updownarrow}+n_{\leftrightarrow}}{2}kd\right). \tag{15}$$

The $y$-component of the output field is found similarly as

$$E_y^{(\mathrm{out})} = \left[E_x\sin\gamma\cos\gamma\left(e^{-\frac{i\Delta nkd}{2}} - e^{\frac{i\Delta nkd}{2}}\right) + \right.$$

$$\left. + E_y\, e^{i\Phi}\left(\sin^2\gamma\, e^{\frac{i\Delta nkd}{2}} + \cos^2\gamma\, e^{-\frac{i\Delta nkd}{2}}\right)\right]\times$$

$$\times\exp\left(i\frac{n_{\updownarrow}+n_{\leftrightarrow}}{2}kd\right). \tag{16}$$

In the case of the proper choice of the grating thickness, we have the necessary condition for a half-wave plate realization: $\Delta nkd = \pi$. Therefore,

$$E_x^{(\mathrm{out})} = \left[iE_x\left(\cos^2\gamma - \sin^2\gamma\right) - 2iE_y\sin\gamma\cos\gamma\, e^{i\Phi}\right]\times$$

$$\times \exp\left(i\frac{n_{\updownarrow}+n_{\leftrightarrow}}{2}kd\right), \quad (17)$$

$$E_y^{(\mathrm{out})} = \left[-2iE_x \sin\gamma\cos\gamma + iE_y\, e^{i\Phi}\left(\sin^2\gamma - \cos^2\gamma\right)\right]\times$$

$$\times \exp\left(i\frac{n_{\updownarrow}+n_{\leftrightarrow}}{2}kd\right). \quad (18)$$

The generic last phase term can be omitted as equal for the both field components. Using simple transformations, we come to the expressions

$$E_x^{(\mathrm{out})} = iE_x \cos 2\gamma - iE_y \sin 2\gamma\, e^{i\Phi}, \quad (19)$$

$$E_y^{(\mathrm{out})} = -iE_x \sin 2\gamma - iE_y\, e^{i\Phi}\cos 2\gamma. \quad (20)$$

The verification shows the energy conservation. Both components have the harmonic dependence on the angle $2\gamma$, which is of great importance for the present analysis. The angle $\gamma$ can be regarded as a governing parameter: for instance, a variation of $\gamma$ in the time domain results in the phase and, therefore, frequency variations in the output wave [5].

Turning to the situation of a polarization grating, we can replace the angular ($\gamma$) dependence of the output field by the spatial one, according to the relation $\gamma = Kx/2$, where $K$ is the grating wave number: $K = 2\pi/\Lambda$.

In the case of the input circularly polarized light, $E_x = E_y = E$ and $\Phi = \pm\pi/2$. Thus, we have

$$E_x^{(\mathrm{out})} = iE(\cos Kx - i\sin Kx) = Ee^{-iKx \pm i\pi/2}, \quad (21)$$

$$E_y^{(\mathrm{out})} = E(\cos Kx - i\,\sin Kx) = Ee^{-iKx}. \quad (22)$$

The obtained result indicates the inversion of the chirality of the polarization state and the linear phase dependence of the output wave on the coordinate $x$. Therefore, only one diffracted order exists:

$$\mathbf{E}^{(\mathrm{out})} = i\,(\hat{x} - i\hat{y})\,Ee^{-iKx}. \quad (23)$$

The sign of the deviation angle from the initial direction of wave propagation is determined by the chirality of the circular polarization of the input wave.

In the case of a linearly polarized input wave, $\Phi = 0$, and $E_x = E\cos\alpha$, $E_y = E\sin\alpha$, where $a$ is the azimuth angle of the plane of polarization, we get

$$E_x^{(\mathrm{out})} = iE_x \cos Kx - iE_y \sin Kx =$$

$$= \frac{iE_x - E_y}{2}e^{iKx} + \frac{iE_x + E_y}{2}e^{-iKx}, \quad (24)$$

$$E_y^{(\mathrm{out})} = -iE_x \sin Kx - iE_y \cos Kx =$$

$$= -\frac{E_x + iE_y}{2}e^{iKx} + \frac{E_x - iE_y}{2}e^{-iKx}. \quad (25)$$

Two diffraction orders exist: the first order has the exponent $e^{iKx}$, and the minus first order has the exponent $e^{-iKx}$. The combination of the corresponding terms gives the following expressions for the complex amplitudes of the diffracted orders:

$$\mathbf{E}_1^{(\mathrm{out})} = \frac{i}{2}E\,(\hat{x} + i\hat{y})\,e^{i(Kx+\alpha)}, \quad (26)$$

$$\mathbf{E}_{-1}^{(\mathrm{out})} = \frac{i}{2}E\,(\hat{x} - i\hat{y})\,e^{-i(Kx+\alpha)}. \quad (27)$$

The amplitudes of both diffracted orders are equal irrespective of the angle $\alpha$, and the difference is seen in the chirality of the circular polarization and in their phases.

In the general case, an elliptically polarized wave is split by a half-wave grating into two circularly polarized diffracted orders. In this sense, the half-wave polarization grating separates the incident light into two different spatial channels according to the shares of the circular components with opposite chiralities in the input wave. Even with a natural unpolarized light, the element will form two circularly polarized diffracted beams (for a spectral region satisfying the half-wave working regime).

Let us assume now some deviation from the exact half-wave condition, which can occur, for instance, due to a variation of the thickness $d$ or the readout wavelength. Taking the deviation measure in phase units $2\delta$, we write, without any restriction of small $\delta$, the phase term in Eqs. (15) and (16) as $\Delta nkd = \pi + 2\delta$ and obtain the result in the form

$$E_x^{(\mathrm{out})} = iE_x\,(\cos 2\gamma\cos\delta + i\sin\delta) -$$

$$-iE_y \sin 2\gamma\cos\delta\exp(i\Phi), \quad (28)$$

$$E_y^{(\mathrm{out})} = -iE_x \sin 2\gamma\cos\delta - iE_y\times$$

$$\times(\cos 2\gamma\cos\delta - i\sin\delta)\exp(i\Phi). \quad (29)$$

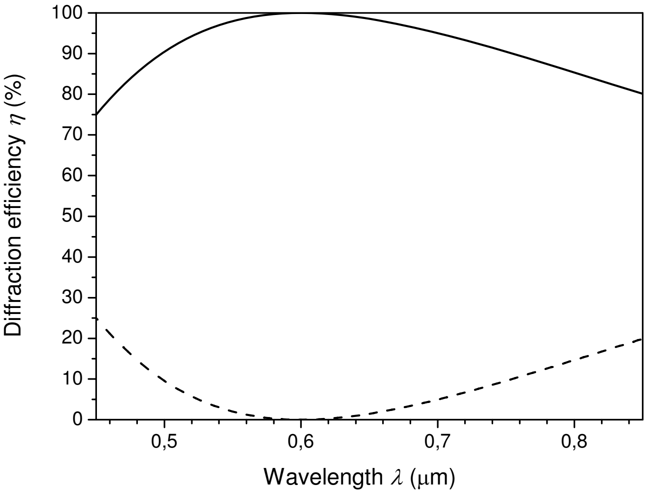


Fig. 7. Calculated diffraction efficiency of the polarization grating tested by a circularly polarized wave with the wavelength $\lambda$ (solid line) and the zero-order transmission (dashed line)

For the periodic grating, $\gamma = Kx/2$. Therefore, the output field appears in a superposition of diffracted waves,

$$\mathbf{E}^{(\mathrm{out})} = i\frac{\cos\delta}{2}(E_x + iE_y e^{i\Phi})(\hat{x} + i\hat{y})e^{iKx} +$$

$$+i\frac{\cos\delta}{2}(E_x - iE_y e^{i\Phi})(\hat{x} - i\hat{y})e^{-iKx} - (\hat{x}E_x + \hat{y}E_y e^{i\Phi})\sin\delta, \quad (30)$$

where the first term is the field description of the first diffracted order, the second term describes the minus first diffraction order, and the third one corresponds to the zero order (transmitted wave).

Then we apply the general solution (30) to the case of a circularly polarized input wave ($E_x = E_y = E$, $\Phi = \pi/2$, $\mathbf{E}^{(\mathrm{in})} = E(\hat{x} + i\hat{y})$):

$$\mathbf{E}^{(\mathrm{out})} = iE\cos\delta(\hat{x} - i\hat{y})e^{-iKx} - E\sin\delta(\hat{x} + i\hat{y}). \quad (31)$$

Instead of a single diffracted order in Eq. (21), a zero order (directly transmitted wave) appears now as well with the amplitude proportional to $\sin\delta$. Paradoxically, this wave does not exhibit any variation of the polarization state. The diffracted order possesses a circular polarization with the chirality opposite to the input one. Its amplitude is reduced, according to the factor $\cos\delta$.

In the case of the linear polarization of an input wave, $\mathbf{E}^{(\mathrm{in})} = E(\hat{x}\cos\alpha + \hat{y}\sin\alpha)$, Eq. (30) yields

$$\mathbf{E}^{(\mathrm{out})} = \frac{i\cos\delta}{2}Ee^{i\alpha}(\hat{x} + i\hat{y})e^{iKx} +$$

$$+\frac{i\cos\delta}{2}Ee^{-i\alpha}(\hat{x} - i\hat{y})e^{-iKx} - E(\hat{x}\cos\alpha + \hat{y}\sin\alpha)\sin\delta. \quad (32)$$

The comparison with solution (26), (27) shows the diminishing of diffracted wave amplitudes and the appearance of the zero order of diffraction. Figure 7 shows the relative intensities of the diffracted beams (first and zero orders of diffraction) in the spectral interval around the readout wavelength $\lambda_0$ satisfying the half-wave condition $\lambda_0/2\Delta nd$. The intensity of the zero order of diffraction vanishes under this condition, and the diffraction efficiency reaches 1 for a single diffracted order. For a circularly polarized readout beam with an arbitrary wavelength $\lambda$, the dependences derived from Eq. (28) are just $\cos^2(\pi\lambda_0/2\lambda)$ for the zero order and $\sin^2(\pi\lambda_0/2\lambda)$ for the diffracted order. In the visible spectrum with $\lambda_0 = 0.6$ $\mu$m, the diffraction efficiency exceeds 75%.

To conclude this paragraph, we can state that, even for a nonmonochromatic and chaotically polarized wave, the polarization grating will work as an efficient generator of circularly polarized waves which appear in the diffracted orders.

## 5. Nonperiodic Distributions

A variation of the birefringence axis orientation in the $XY$ plane allows one to control the transversal phase of an output wave. As a simple example, the realization of an optical wedge (or prism) is possible for a periodic distribution given by Eq. (7). The whole incident wave is deflected (diffracted) from the initial direction. A biprism function looks similar, but becomes an odd function.

In the next step, an analog of a cylindrical lens can be produced with the quadratic approximation of the phase dependence. The equation for the director line (5) transforms to

$$\frac{dF(x)}{dx} = \tan(Kx^2), \quad (33)$$

where $K$ stands just for a scale coefficient. The numerical integration of Eq. (33) gives a picture similar to that shown in Fig. 4, but as an odd function with varying period, as shown in Fig. 8.

In order to generate a spherical lens, we have to solve the equation for the director line for a two-dimensional function $F(x,y)$

$$\frac{dy}{dx} = \tan\left[K(x^2 + y^2)\right]. \quad (34)$$

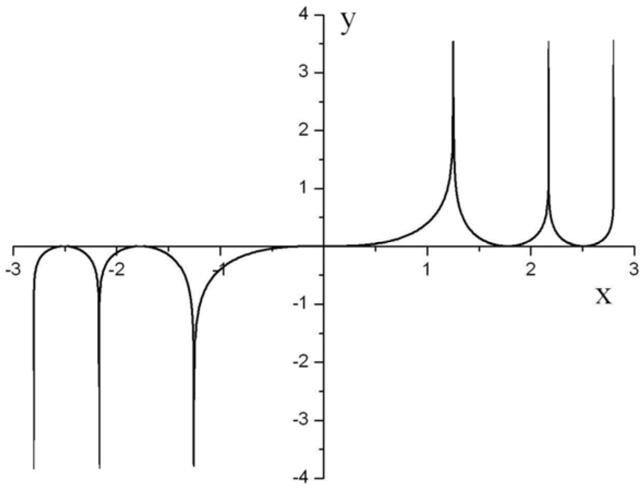


Fig. 8. Calculated plot of dependence (33) which shows the director line in the case of cylindrical lens formation

In polar coordinates ($\rho$,$\varphi$), it takes the form

$$\frac{d\varphi}{d\rho} = \frac{\tan\left(K\rho^2 - \varphi\right)}{\rho}. \tag{35}$$

The numerical integration of Eq. (35) was used for plotting a family of director lines, as shown in Fig. 9.

The focusing properties of the element are determined by the geometric scale of a hologram structure, i.e. the parameter $K$ in Eq. (34).

## 6. Conclusions

The unique properties of phase polarization elements make them useful tools for the control over light waves. They became now a commercial product for various applications [6, 7]. The further investigation of diffractive polarization elements and their combinations is very perspective for practical goals. Moreover, traditional optics can be re-designed with the polarization holograms.

There is at least one problem in the exploitation of diffractive polarization elements for optical transformations: they are wavelength-selective and, therefore, can be used only for monochromatic light waves. However, this restriction is not severe. The violation of the exact half-wave condition results in the appearance of a directly transmitted wave (zero order of diffraction) and in diminishing the diffraction efficiency, but does not affect the circular polarization state in the first (minus first) diffraction orders. Fortunately, a decrease of the diffraction efficiency is rather moderate in the whole visible spectrum. On the other hand, an electronic control is possible to satisfy necessary diffraction conditions.

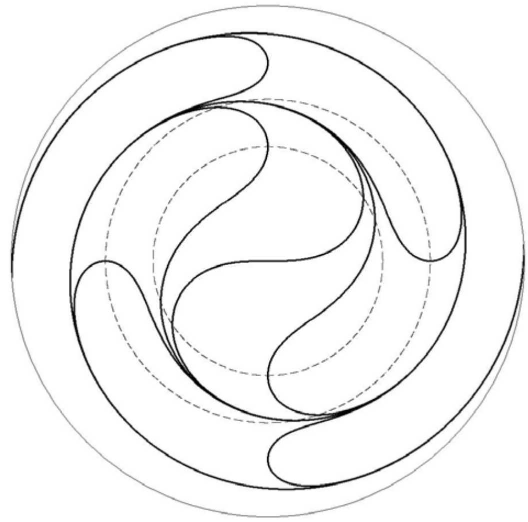

Fig. 9. Calculated family of director lines for a pattern producing the focusing (defocusing) spherical lens regime. Dashed circles are shown to indicate the equal orientation of the birefringence axis: the inner circle corresponds to $\gamma = \pi/2$, second circle to $\gamma = \pi$. At the center of the pattern, $\gamma = 0$

In the domain of quantum optics, the transformation of a single photon with any polarization state into the circular polarization state can be achieved, or sorting the photons by their polarization is easily available.

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# ОПТИЧНІ ЕЛЕМЕНТИ НА БАЗІ ФАЗОВИХ ПОЛЯРИЗАЦІЙНИХ ҐРАТОК

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Р е з ю м е

Розглянуто основні принципи поляризаційної голографії та сконцентровано увагу на тонкі фазові голограми, у яких двозаломлення в точності досягає властивості напівхвильової пластини. Проаналізовано метод керування фазою за допомогою оптичних елементів з просторовим розподілом осі двозаломлення. "Напівхвильова" поляризаційна голограма може досягати 100%-ної дифракційної ефективності у єдиному порядку дифракції. Просторова орієнтація осі двозаломлення визначена для циліндричних та сферичних фокусуючих елементів.