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Comparison of properties inherent to wave plates and Fresnel rhomb

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Abstract. Principles of functioning and technical characteristics of wave plates and Fresnel rhomb are analyzed, and the properties of these optical elements are compared. Main fields of application are discussed.

Keywords: wave plate, Fresnel rhomb, spectral region, polarization, ellipse of polarization.

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1. Introduction

Precise control of the polarization is of principal importance in the fields of solar polarimetry, optical communications, bio- and medical visualization of images, identification of military targets, chemical analysis, spectral filtration, etc. [1]. For these purposes quarter-, half-wave plates and Fresnel rhomb are used. Usually wave plates are applied in the optical schemes for polarization analysis and control in comparatively narrow spectral regions, e.g., quarter-wave plates are used in optical isolators, electro-optical modulators, interferometers, ellipsometers, in the systems for image processing [2]. Very thin wave plates are used in the systems of optical communication for reading-out and writing information on digital discs. They are perfect for using in multiplexing systems as variable attenuators, circulators, analyzers [2] and as elements for polarization control [3].

Fresnel rhombs are widely used for the analysis and control of polarization in a wide spectral region. For example, they are used in the systems for studies of magnetism and atmosphere of stars [4], for the search of planets around the stars [5], for studies polarization influence on nonlinear absorption [6].

There are plenty of types of commercial wave plates and Fresnel rhombs. To make the best choice of a polarization device, one must know both the basic principles of its operation and technical characteristics (spectral and temperature region, angle of incidence, aperture, etc.) as well as influence of its material characteristics and tolerances on parameters of wave plates and Fresnel rhombs. Hereafter, we present the detailed analysis of the operation principles of the wave plates and Fresnel rhombs, provide the comparison of their properties, advantages and drawbacks, and briefly discuss their applications in various fields.

2. Phase (wave) plates

A wave plate is a parallel plate of birefringent crystal with the axis aligned along the surface of the plate (Fig. 1). When the linearly polarized incident light (E_0) propagates along the perpendicular to the plate and the azimuth of its polarization $\varphi \neq \pi/2$, then two waves with orthogonal polarization occur in the crystal (ordinary and extraordinary). The electric field in these components ($E_\perp$, $E_\parallel$) is as follows:

$$E_\perp = E_0 \cos\varphi \sin(\omega t), \quad E_\parallel = E_0 \sin\varphi \sin(\omega t - \delta). \qquad (1)$$

Due to the different velocities of these waves in the crystal, one of the waves is retarded and the phase difference δ appears. If the thickness of the plate is d, then

$$\delta = 2\pi (n_e - n_o) d / \lambda, \qquad (2)$$

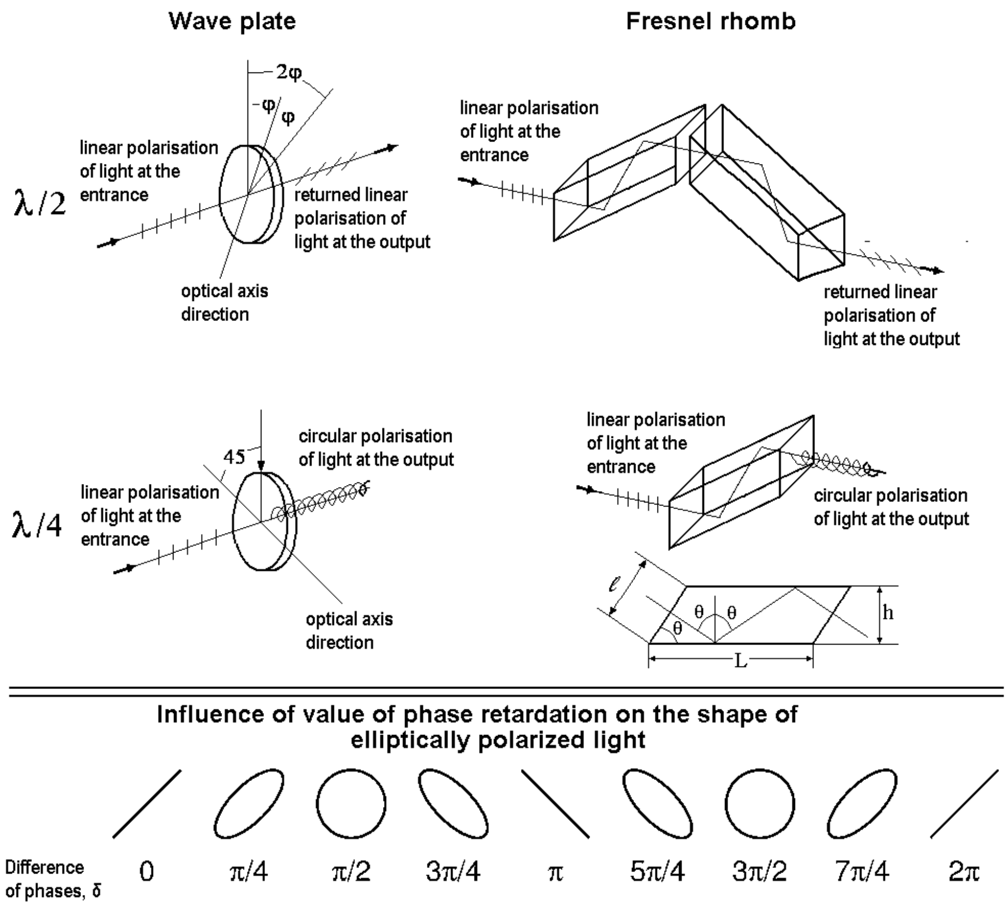

Fig. 1. Illustration of wave plate and Fresnel rhomb influence on light polarization.

where λ is the wavelength, n_o and n_e are the refractive indexes of the ordinary and extraordinary waves, respectively. If after passing through the plate $\delta = \pi / 2$, the plate is named a quarter-wave plate. For this plate the transmitted wave is

$$E_\perp = E_0 \cos\varphi \sin(\omega t), \quad E_\parallel = E_0 \sin\varphi \cos(\omega t), \tag{3}$$

where ω is the frequency, t is the time.

The formula (3) represents the ellipse equation in the parametric form. According to Eq.(3) the ellipticity degree depends only on the azimuth of polarization φ. It can be varied by rotating the quarter-wave plate. As a result, polarization of transmitted light gradually varies from the linearly to circularly one (Fig. 1).

The wave plate that is characterized by $\delta = \pi$ is named a half-wave plate. In this case, the electric field components ($E_\perp$, $E_\parallel$) of the transmitted wave are:

$$E_\perp = E_0 \cos\varphi \sin(\omega t), E_\parallel = E_0 \sin\varphi \sin(\omega t) \ . \tag{4}$$

According to Eqs (1)-(4) the half-wave plate does not change the amplitude of electromagnetic wave. If the azimuth of incident light equals ($-\varphi$), then the azimuth of transmitted light will be equal φ; this is equivalent to the rotation of polarization plane by 2φ (Fig. 1).

Wave plates are fabricated from optically perfect polimer films (3MPP2500^{TM} polyester [7]), polyethelene tetraftalate [7], polymethylmethacrylate [8] and uniaxial crystals (e.g., quartz, MgF_2, CdS). The operating spectral range for polymeric wave plates is 360-1400 nm [8, 9]. The light energy density for the pulses of 10 ns duration must not exceed 300 mJ/cm^2 within the visible range, while for infrared range it must not exceed 500 mJ/cm^2 [10]. Diameter of polymeric wave plates varies from 5.0 up to 380 mm [10]. The quartz wave-plates operate within the range 193–2500 nm, MgF_2 – (400–6000) nm, CdS – (500–14000) nm. Technically the wave plates are fabricated as single plates of the zero and higher orders and as achromatic plates.

2.1. Zero-order wave plates

The thickness d of the quarter- and half-wave plates of the zero order equals

$$d = \lambda[4(n_e - n_o)]^{-1}, d = \lambda[2(n_e - n_o)]^{-1}. \tag{5}$$

At λ = 500 nm the thicknesses of quarter- and half-wave plates equal 13.7 and 27.4 μm, respectively. The plates of these thicknesses are very fragile and are difficult to fabricate. These shortcomings could be eliminated by gluing or fabricating optical contact thin plates of uniaxial crystal (with the thickness adjusted in accordance with (5)) on thick (about several millimeters) glass plates. One more type of zero-order wave plates can be obtained by combining two uniaxial crystalline plates with the thickness of about 2 mm. The optical axes of these plates must be perpendicular to each other. As a result, the action of one plate compensates action of another plate and the only difference in their thicknesses determines properties of the zero-order wave plates. This difference must provide either $\delta = \pi/2$ or $\delta = \pi$.

There are differences between the wave plates that contain glued parts, or parts in optical contact, or parts separated by an intermediate optical layer. The wave plates with glued parts can be damaged by cw laser with the power density 1 W/cm^2 [12]. The power density threshold for the wave plates with optical contact is 100-200 MW/cm^2 [10, 12]. The power density threshold for the wave plates with an intermediate air layer is 500 MW/cm^2 [10] for irradiation with 20 ns laser pulses. Technical characteristics of the zero-order wave plates are listed in Table 1.

2.2. High-order retardation wave plates

The wave plates characterized by $\delta = (2N + 1/2)\pi$ or by $\delta = (2N + 1)\pi$ (N = 1, 2, 3…) are named high-order quarter-wave or half-wave plates, respectively. The thickness of the quarter- or half-wave plates is estimated by the following formulae:

$$d = \lambda\,[4N + 1]\,[4(n_e - n_o)]^{-1},$$
$$d = \lambda\,[2N + 1]\,[2(n_e - n_o)]^{-1}. \qquad (6)$$

For λ = 500 nm the thickness of the 20-th order quarter-wave plate equals 1.1 mm. The damage threshold for these plates exceeds 500 MW/cm^2 [10]. Their characteristics are listed in Table 1.

2.3. Achromatic retardation wave plates

Achromatic wave plates consist of two plates of different uniaxial crystals, e.g., one plate is made of quartz, another – of MgF_2. These materials are characterized by different refractive index dispersion. This provides insensitivity to the variation of wavelength. Components of achromatic wave plates can be glued, constructed optical contact or separated by the layer of air. Typical characteristics of these wave plates are listed in Table 1.

2.4. Systematic errors of retardation wave plates

While choosing the type of wave plates, the preference should be given to those wave plates that are characterized by the minimum sum of random and systematic errors in δ. The random errors could be minimized by optimization of wave plate holders and light signal registration system. The systematic errors are caused by the influence of external factors and light propagation conditions on the parameters (n_o, n_e, d, λ) that determine the value of δ (Eq. (1)). The most important systematic errors are the following.

2.4.1. Wavelength

According to Eq. (2) in single wave plates the variation of retardation caused by change in wavelength can be estimated using the formula [15]

Table 1. Typical parameters of quarter- and half-wave plates.

Parameter	Type of the plate		
	High-order [13]	Zero-order [13]	Achromatic [13]
Material	Crystalline quartz	Crystalline quartz	Crystalline quartz and MgF_2
Thickness	>1 mm [12]	0.2–0.5 (crystal plus glass)	0.5–1 mm for each single crystal
Tolerance to size	+0.0; –0.2 mm [12]	+0.0; –0.2 mm	+0.0; –0.2 mm
Wave distortion	$\lambda/8$ at λ = 632.8 nm	$\lambda/8$ at λ = 632.8 nm	$\lambda/8$ at λ = 632.8 nm
Tolerance to retardation	$\lambda/600$–$\lambda/200$ at 20 °C	$\lambda/500$ – typical	Up to $\lambda/100$ at chosen wavelength
Spectral range	240–2100 nm	240–2100 nm	VIS: 465–610 nm* NIR: 700–1000 nm* IR: 1200–1650 nm*
Typical operating spectral interval	±100 nm [2]	±50 nm [2]	±300 nm [2]
Parallelism	≤1″	≤0.5″ [12]	Less than 10″
Transmittance band width	<2 nm at λ = 632.8 nm [10]	10 nm at λ = 800 nm for $\lambda/500$ [10]	300 nm at λ = 850 nm for $\lambda/500$ [10]
Anti-reflective coating	$R \le 0.2\%$ for the central wavelength	$R \le 0.2\%$ for the central wavelength	$R \le 0.2\%$ for the central wavelength [14]
Surface quality	20–10 scratches and cleavages	20–10 scratches and cleavages	20–10 scratches and cleavages
Damage threshold	10 J/cm^2, 20 ns, 20 Hz at 1064 nm [10]	10 J/cm^2, 20 ns, 20 Hz at 1064 nm [10]	2 J/cm^2, 20 ns, 20 Hz, 500 kW/cm^2 at 1064 nm [10]

Note. VIS, NIR, IR – visible, near-infrared and infrared spectral ranges, respectively.

$$\frac{d\delta}{d\lambda} = \delta\left[\frac{d(n_e - n_o)}{(n_e - n_o)d\lambda} - \frac{1}{\lambda}\right]. \tag{7}$$

While in compound plates (glass plus uniaxial crystal) and in achromatic plates, the variation of retardation can be estimated using the formula [15]

$$\frac{d\delta}{d\lambda} = \delta_1\left[\frac{d(n_{e1} - n_{o1})}{(n_{e1} - n_{o1})d\lambda} - \frac{1}{\lambda}\right] - \delta_2\left[\frac{d(n_{e2} - n_{o2})}{(n_{e2} - n_{o2})d\lambda} - \frac{1}{\lambda}\right]. \tag{8}$$

In Eqs (8) indexes 1 and 2 denote the refractive indices of the first and second plates, respectively.

2.4.2. Angle of incidence

There are two reasons of deflection of light beam relative to the precise orthogonality to the crystal optical *c*-axis, namely: i) the optical axis is not precise parallel to the input wave plate surface; ii) the angle of incidence on the input wave plate surface is not exactly 90°. In both cases *E*-vector of the ordinary wave remains perpendicular to the *c*-axis and its refractive index is equal to n_o. However, the refractive index of the extraordinary component is [15]:

$$n_{eff} = n_e n_o\left[n_e^2\cos^2\theta + n_o^2\sin^2\theta\right]^{-1/2}, \tag{9}$$

where θ is the angle between *c*-axis and light propagation direction in medium. To estimate the retardation one can use Eq. (2) introducing the effective value of refractive index n_{eff} instead of n_e.

2.4.3. Thermal effects

The values of the parameters n_e, n_o and d depend on temperature. It means that the retardation (Eq. (2)) also depends on temperature, e.g., when the temperature of the quartz quarter-wave plate changes by one degree the retardation changes approximately by 0.00011% [16], and for polymeric plate – by (0.02–0.30)%. Typical temperature coefficient of the retardation for high-order quartz plates is 0.0025 λ/°C [16].

2.4.4. Other effects

Presence of refractive index inhomoheneities in the bulk of the plates and the roughness of the faces cause some depolarization of light and wave front deformation in transmitted light. These effects can be minimized by choosing optically homogeneous material and by high quality of surface polishing. A wave plate has two parallel faces, thus it is a Fabri-Perrot ethalon. Influence of the interference effects on the retardation in the interferometer could be minimized by antireflective coating of the surfaces. In typical achromatic plated with the air separating layer, transmitted light comprises 98% in the visible range.

3. Fresnel rhomb

To control polarization of light, Fresnel rhombs are also used. Their action is based on the phenomenon of total internal reflection. If the incidence angle θ (Fig. 1) of the linearly polarized beam is larger than the angle of total internal reflection, then two waves occur in the reflected beam; the *E*-vectors of these waves are perpendicular to each other (*s* and *p* components of light beam). The phase difference δ between these two components can be estimated using the formula [17]

$$\tan(\delta/2) = \cos\theta\,[\sin^2\theta - n_{21}{}^2]^{1/2}\,[\sin^2\theta]^{-1}, \tag{10}$$

where n_{21} is the refractive index of more optically dense medium relatively to less optically dense medium.

Maximum phase difference δ_{max} depends only on n_{21}

$$\tan(\delta_{max}/2) = \left[1 - n_{21}^2\right]\cdot\left[2n_{21}\right]^{-1}. \tag{11}$$

In many materials the value $\delta_{max} = \pi/2$ can be achieved only after two total internal reflections. This is the reason of the rhombic shape of the device (Fresnel rhomb) for the polarization control.

If the incidental beam is linearly polarized, then at $\delta_{max} = \pi/2$ transmitted light will be circularly polarized (Fig. 1) and vice versa. Thus, the rhomb acts as the wave plate with $\delta = \pi/2$. By rotating the polarization plane of the incident beam one can vary the ellipticity of transmitted light from zero (linearly polarized light) to unity (circularly polarized light) (Fig. 1).

The tandem of two rhombs (Fig. 1) acts as a half-wave plate. Indeed, the first rhomb transforms linearly polarized light into elliptically polarized one, and the second rhomb transforms elliptically polarized light into linearly polarized one. Using the tandem of Fresnel rhombs one can rotate the polarization plane of light by 360 degrees.

3.1. Optical material for rhombs

Rhombs are fabricated using optically perfect bulk isotropic materials with the known refractive index dispersion. Linear absorption and scattering of light in the transparence range must be minimal. Typical materials for rhombs are fused quartz (190-2500 nm range) [18], glasses BK7 [18] and K8 (190-2500 nm range). The rhombs for infrared range are made of zinc selenide (ZnSe) for the 6-14 μm range; cadmium telluride (CdTe) and KRS-5 for the range 6-18 μm [5]. The technology of ZnSe growth is well established; its price is reasonably low. Suitability of CdTe for rhombs is limited by the problems with qualitative polishing. Low dispersion of KRS in the infrared range makes this material the ideal choice for Fresnel rhombs fabrication. The imperfections of this material are the toxicity, fragility, polishing difficulties.

3.2. Technical parameters of Fresnel rhombs

We will illustrate the specific features of rhomb parameters calculation using K8 glass as an example. Using the known tabulated dependence of the refractive index on the wavelength (Fig. 2, dots) [19], we will approximate this dependence by the 6-th order polynomial (Fig. 2, line). Root-mean-square deviation of the approximation of K8 glass refractive index dispersion equals $3.6 \cdot 10^{-4}$. Next step is to find the dependence δ_{max} versus λ using Eq. (11) (Fig. 3). On the long-wave side of the spectral range, where the rhomb can be used as a quarter-wave plate, this range is limited by the occurrence of vibration absorption lines (Table 2). On the short-wave side, it is limited by the fundamental absorption edge.

According to Fig. 1 at the normal incidence of light on the input face of the rhomb, the angle of light incidence on the long face of the rhomb is equal to the angle θ at the rhomb base. Substituting the value of δ_{max} into (10), one obtains that θ has two values 53°50′ and 49°46′. Taking into account that the angle of incidence must be less than total internal reflectance angle, we choose the value θ = 53°50′ (Table 2).

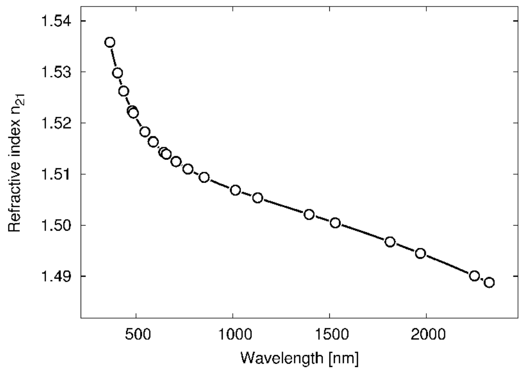

Fig. 2. Refractive index dispersion for the glass K8 (dots). The solid line corresponds to the approximation by the 6-order polynom.

The intensity distribution in the beam cross-section for most lasers is Gaussian by shape, i.e.:

$$I = I_{\max} \exp\left[-\ln 2 (r/r_0)^2\right], \qquad (12)$$

where I_{max} is the maximum value of the intensity, r is the distance from the beam center, r_0 is the radius at $I = I_{max}/2$. At the spectroscopic measurements the contribution of the intensity with $I \le I_{max}/e^4$ is usually neglected. The value $I = I_{max}/\exp(+4)$ is usually achieved when the distance from the center of the beam is equal to $r_e = 2 r_0 \left[\ln 2\right]^{-1/2}$. It means that the minimum size of the square face must be $\ell = 2r_e = 4 r_0 \left[\ln 2\right]^{-1/2}$. It is seen from Fig. 3 that the height of the rhomb is $h = \ell \sin\theta$ and its base length is $L = 2h \tan\theta$. The obtained formulae can be used to calculate sizes of Fresnel rhombs made of K8 glass (Table 3) and to illustrate their dependence on the cross-section of the laser beam. Other parameters of Fresnel rhombs made of K8 glass are listed in Table 2. Values of the angle at the base of the rhomb and parallelism of faces are controlled by goniometer of GS – 1 type.

There are many types of Fresnel rhombs. Typical parameters of commercial Fresnel rhombs are listed in Table 2. It is seen that the recommended operating spectral range of any Fresnel rhomb is much larger than the range of zero- and high-order wave plates and is close to the range of achromatic plates (compare the Tables 1 and 2). Usually the commercial rhombs guarantee 90°±2° retardation within the recommended operating spectral range. Due to this reason the recommended operating range is much narrower than the transparence range of the material. Moreover, the sizes of rhomb faces can be varied in accordance with customer's demands.

Table 2. Parameters of Fresnel rhombs.

Parameter	Material		
	Fused quartz	Glass BK7	Glass K8
Spectral range	(210–400) nm [18]	(400–2000) nm [18]	(365–2500) nm for λ/2 (365–16600) nm for λ/4
Angle allowance		3′ [20]	1′
Size allowance	+0.0; –0.2 mm [21]	+0.0; –0.2 mm [21]	+0.0; –0.2 mm
Flatness	λ/10 at λ = 632.8 nm [21]	λ/10 at λ = 632.8 nm [21]	λ/10 at λ = 632.8 nm
Allowance for retardation	±2° [18]	±2° [18]	±3°
Anti-reflective coating	$R \le 0.2\%$ for the central wavelength	$R \le 0.2\%$ for the central wavelength	$R \le 0.5\%$ at λ = 632.8 nm
Surface quality	20–10 scratches and cleavages [21]	20–10 scratches and cleavages [21]	< 20 scratches and cleavage
Allowance for faces parallelism	< 2″ [22]	< 2″ [22]	< 2″
Deviation	±0.5° [22]	±0.5° [22]	±0.3° at λ = 632.8 nm
Maximum peak intensity	200 MW/cm^2 [23]	200 MW/cm^2 [23]	200 MW/cm^2
Maximum cw intensity	100 W/cm^2 [23]	100 W/cm^2 [23]	
Free aperture diameter	10 mm [22, 24]	10 mm [22, 24]	15 mm

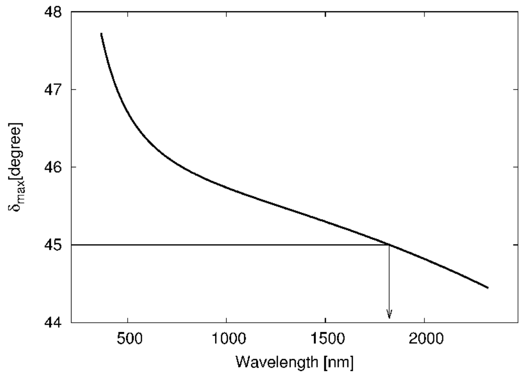

Fig. 3. Dependence of δ_{max} on the wavelength.

Table 3. Overall sizes of Frenel rhombs made from glass K8.

$D_0 = 2r_0$, mm	ℓ, mm	h, mm	L, mm
3	7.2	5.8	15.3
10	24.0	19.4	51.2
15	36.0	29.1	76.8

Note. D_0 is the diameter of laser beam at $I = I_{max}/2$.

3.3. Sources of errors

The criterion to choose the basis of design Fresnel rhomb is minimal value of the sum of random and systematic errors in retardation. The value of random error can be minimized by optimization of the rhomb shape and holder as well as by optimization of the light registration system. Systematic errors are caused by uncertainty of the incidence angle of light at the reflective face (see Eq. (10)); dependence of refractive index, and, consequently, of retardation on temperature and wavelength; by occurrence of refraction from the faces; rhomb shape distortions.

3.3.1. Angle of incidence

According to Eq. (10) the variation of the angle of incidence θ leads to the changes in retardation. As a result, Fresnel rhombs are extremely sensitive to the changes of the angle of incidence (as small as angle minutes) [5]. This sensitivity should be taken into account when single Fresnel rhombs are used to control the ellipticity of light beams from real sources because these beams are always somewhat divergent. Double Fresnel rhombs are insensitive to the changes of the angle of incidence. Couples of reflections in two rhombs complement each other (see Fig. 1). It means that the increase of the angle of incidence due to two total internal reflections in the first rhomb is compensated by decrease of the angle of incidence due to two total internal reflections in the second rhomb. As a result the retardation is equal to zero. Thus, double rhombs allow the variation of incident light inclination in the wide (up to several degrees) range. There is also a certain probability that two rhombs will be tilted relative to each other, and this will influence the retardation value. As it is shown in [24], at typical allowances for the angle at the rhomb base and for rhomb alignment, the angle between the output face of the first rhomb and the input face of the second rhomb can vary from 0.2° to 0.8°. This tilt causes the error of retardation value less than 0.002°.

3.3.2. Reflection at the input and output faces

Each rhomb can be considered as a Fabri-Perrot etalon if its input and output faces are exactly parallel. The allowances for the parallelism of the faces and for the angle at the rhomb face permit to neglect interference of light inside the rhomb. Application of anti-refractive coatings to the rhomb faces also favors neglecting of interference effects.

3.3.3. Spectral range

Dispersion of the refractive index n_0 causes the dependence of retardation δ on wavelength. By fixing the range variation δ we practically determine the operating spectral range of Fresnel rhomb. Typical operating spectral range for visible light is 300 nm if retardation δ variation is ±2° [5]. The width of the operating range can be increased by weakening n_{21} dependence on wavelength. For this purpose the reflecting faces of the rhomb are covered with a thin layer of the material that is characterized by the refractive index dispersion close to that of the rhomb. E.g., by coating glass with a thin layer of MgF_2 (about 23 nm) the retardation value of 90±0.5° can be achieved in the spectral range from 370 up to 1000 nm (for the comparison: the retardation of classical plates deviated from 90° by about 20° [4]).

3.3.4. Influence of temperature

The refractive index of Fresnel rhombs depends on temperature. Mostly, the refractive index of isotropic materials weekly depends on temperature, e.g., in the range of room temperatures $dn/dT = +0.24\cdot10^{-5}/°\text{C}$ [26] for glass BK-7, $dn/dT = +0.24\cdot10^{-5}/°\text{C}$ [27] for the fused quartz. For ZnSe, CdTe, KRS-5 at λ = 10.6 µm the value dn/dT is equal to $+6.1\cdot10^{-5}/°\text{C}$, $+10.7\cdot10^{-5}/°\text{C}$, $-9.9\cdot10^{-5}/°\text{C}$, respectively [28]. In accordance with the listed value the change of temperature by ±10 °C will cause variation of n_{12} less than by one thousands. This implies unessential influence of temperature on the retardation value.

4. Comparison of properties inherent to wave plates and Fresnel rhomb

Using the data listed in Tables 1 and 2 one can compare the characteristics of wave plates and Fresnel rhombs for visible and infrared spectral ranges. E.g., at the allowance for retardation equal to 2°, the unitary standard reference table can be used both for achromatic wave plates and Fresnel rhombs in the spectral range 200-300 nm. In the case of the wave plates it is difficult to enlarge this spectral range by simultaneous diminishing allowance for retardation. However, in the case of Fresnel rhombs the deposition of thin layers of MgF_2 on the reflecting faces of a rhomb permits to use the unitary standard reference table within the range (370-1000) nm with the error of polarization plane rotation equal to 0.5° [4]. Yet larger discrepancies occur in the infrared range. Indeed, at the retardation error equal to 2°, the width of the spectral range for the CdS plate equals ±0.1 μm (with the center at 10.6 μm) [28]. Within the spectral range 9.238−10.6 μm the allowance for the retardation is less than 0.08° at normal incidence [29]. Due to this reason Fresnel rhombs are preferable for studies of light polarization in the infrared range that is important for tracking down the planets around the stars and for the analysis of their magnetic field and atmosphere [4, 5].

When choosing the device to control light polarization, the sensitivity to the angle of incidence on the input face is essential. In the case of the quarter-wave plate the inclination of beam by 5° relative to the normal incidence causes the change of retardation by 2° [31]. Double Fresnel rhomb (Fig. 1) is not sensitive to the variation of the incidence angle. It allows inclinations of several degrees relative to the normal incidence. Half-wave plates and single Fresnel rhombs are very sensitive to the inclination of incident beam.

Temperature does not essentially influence the retardation of Fresnel rhombs. On the contrary, the retardation in wave plates depends on temperature.

Deviation of light beam at double rhomb rotation can be as large as ±0.5°. It can be largely diminished by decreasing the allowance for the angle at the base of the rhomb and for the parallelism of faces. There is no deviation or precession of light beam in wave plates [17].

Stability of Fresnel rhombs and wave plates at high power light irradiation is almost the same. It is determined by the stability of the material (for the rhombs with air layer) or by the stability of the glue that connects the components of wave plates or rhombs.

5. Conclusions

Operation and technical parameters of wave plates and Fresnel rhombs have been analyzed. In the case of strict demands to the size and weight of optical systems the wave plates are preferable. First of all, these are the systems for optical communications. In the case of systems for polarization control in the wide wavelength range Fresnel rhombs are preferable. These are polarimeters, the systems for atmospheric studies, for studies of magnetism of the Sun and stars, for the investigation of optical properties of materials.

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