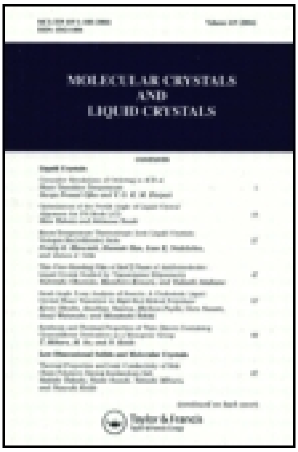

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Angular Dependences of Prism Liquid Crystal Polarizer

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ANGULAR DEPENDENCES OF PRISM LIQUID CRYSTAL POLARIZER

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Abstract The angular dependences of extinction ratio and polarization plane orientation for prism liquid crystal polarizers have been measured for 632.8nm vawelength in the limits of angular aperture. The planar and homeotropic orientations of nematic liquid crystal layer were used.

INTRODUCTION

The knowledge of angular characteristics of linear polarizers is important for different applications that involve noncollimated or off-axis collimated beams. For example, precize measurements for multilayer polarizing beam-splitters cubes (PBSs) were performed by Pezzanity and Chipman.[1] However, the angular dependences of broadband prism liquid crystal polarizers (PLCPs)[2,3] are not investigated. In this paper we report the results of determination of polarization plane orientation in the exit beam of PLCP and measurements of extinction ratio as the function of incidence angles onto the entrance face of polarizer.

EXPERIMENTAL

Figure 1 shows a general scheme of our experimental setup. The linearly polarized 1-mm diameter beam from single-mode He-Ne laser (632,8nm) was additionally "cleared" by Glan-Thompson prism and was incident to the quarter-wave plate that transformed the linear polarization into circular one, i.e. imitated the natural nonpolarized beam. Then laser beam passed the compensator of beam shifting (that arise from the PLCP rotation), and the PLCP under investigation. After leaving the polarizer, the laser beam passed through second Glan-Thompson prism and directed by the collecting lens to the scattering element, placed before the photomultiplier tubes.

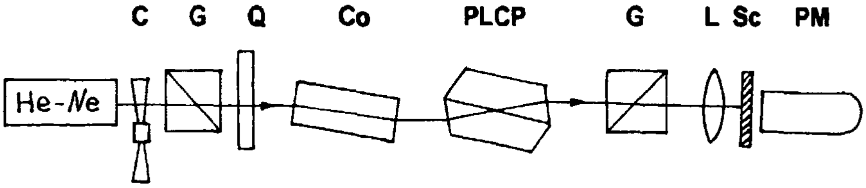

FIGURE 1 The experimental setup: S-shutter, G-Glan-Thompson prism, Q-quarter-wave plate, Co-compensator, L-lens, Sc-scattering plate, PM-photomultiplier tube.

The PLCP could rotate in two orthogonal planes with 0.1degree accuracy. The angles of turning are depicted in Figure 2

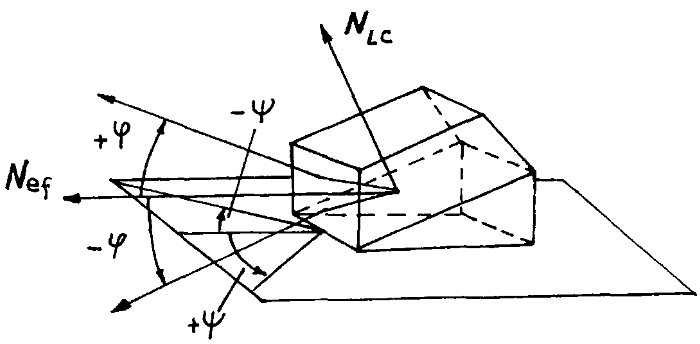

FIGURE 2 The angular coordinates used in experiments : $+\psi$, $-\psi$ - the angles of sample rotation in horizontal plane and $+\varphi$, $-\varphi$ - in vertical plane from normal to entrance face, N_{ef} -normal to entrance face, N_{LC} - normal to NLC layer.

The determination of polarization plane orientation in exit beam of PLCP performed by the rotation of second Glan-Thompson prism. The angular accuracy of this measurements was 0.2 degree. For the measurement of angular dependence of contrast ratio, the quarter-wave plate and second Glan-Thompson prism were removed and tested PLCP was placed in crossed position with first Glan-Thompson prism. The compensator of beam shifting was the planeparallel glass plate, such that its length along the beam direction was equal to PLCP length.

The compensator holder was mechanically connected with sample holder and rotated in opposite directions in the two planes. The scattering plate integrated the measured signal through the surface of PM photocathode in order to further reducing the errors connected with possible displacement of focal spot across the photocathode of PM tube. Finally, to verify the absence of abovementioned systematic angular error, the second compensator mounted in sample holder and both compensators rotated in opposite directions in the limits of considered angular ranges.

For this measurements two samples with homeotropic and planar orientation of NLC were fabricated. Both samples were made from identical heavy glass prisms with 15*15mm aperture. For normal incidence of laser beam onto the entrance face of PLCP the incidence angle onto the glass-NLC layer interface was 68 degrees (see Figure 2). The NLC mixture for each type of orientation was chosen from condition of minimum refraction of transmitted laser beam on two glass-NLC interface. It means that glass refraction index and NLC extraordinary refraction index for this beam direction should be approximately equal.

The main parameters of PLCPs prepared for investigation are listed in Table I. The angular apertures for both samples are nonsymmetrical (are not restricted in -φ direction) due to given condition of magnitudes equality of glass refraction index and NLC extraordinary refraction index. Angular aperture values in Table I are introduced as doubled magnitude of angular aperture in +φ direction.

TABLE I

Type of NLC orientation	Angle θ (degrees)	N_o	N_e	ne(θ)	Angular apert. in air (vert.plane, degrees)
1.Homeotropic	68	1.506	1.674	1.636	4.6
2.Planar	90	1.488	1.642	1.642	10.6
Refraction index of glass				1.644	

Here N_o, N_e - is the principal ordinary and extraordinary refraction indeces; θ is the angle between the optical axis and beam direction in glass for normal incidence.

RESULTS AND DISCUSSION

We have measured the angular dependences for both samples over the range of +/-7 degrees from the normal to entrance faces in horizontal plane and in vertical plane over the ranges of :

+2/-5 degrees for sample 1

+5/-5 degrees for sample 2

The step of angle variation in this measurements was 1 degree for φ and 0.5 degree for ψ.

We have discovered that for the homeotropic orientation of NLC layer the polarization of transmitted beam remained linear for all considered ψ and φ angles. The angular dependences of the polarization plane orientation and extinction ratio for homeotropic NLC layer are shown in Figures 3(a) and 3(b) respectively.

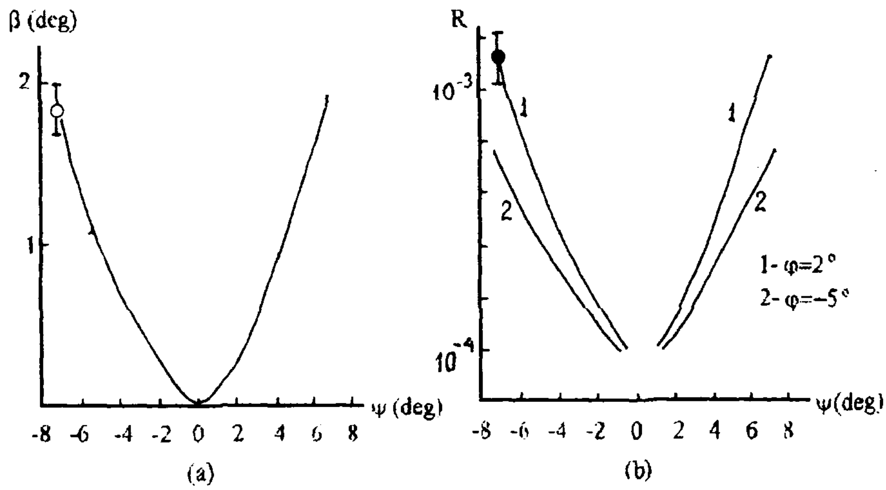

FIGURE 3 β - orientation of polarization plane in exit beam with respect to orientation in entrance beam (a) and R - extinction ratio (b) as a functions of ψ and φ angles for homeotropic orientation of NLC layer.

Figure 3(a) demonstrates turning of polarization plane orientation of exit beam with changing of ψ angle from initial ψ=0 value. This turning is caused by the fact that exit beam polarization direction follows after the optical axis orientation. In our case the change of visual inclination of optical axis with respect to horizontal plane and given beam direction takes place when the sample rotates in this plane. We have observed no dependence of polarization plane position on φ angle over the range of our measurement accuracy.

The angular dependences of extinction ratio (when the PLCP is illuminated by the beam with the prohibited polarization direction) is illustrated in Figure 3(b). The allowed polarization in the exit beam direction appears because of the appearing of non-zero projection of electric-field vector, that characterize the direction of beam polarization, onto the optical axis of the NLC layer. For this type of NLC layer orientation we observed weak dependence of extinction ratio on the φ angle.

For the PLCP with planar orientation we have obtained more complicated situation. Here initially plane-polarized beam after passing through NLC transforms into slight elliptical polarized beam for all incidence directions that differ from direction of normal incidence onto optical axis of NLC layer (i.e. for the incidence out of the plane characterized by ψ =0). In fact, Fig.4a shows the angular difference between

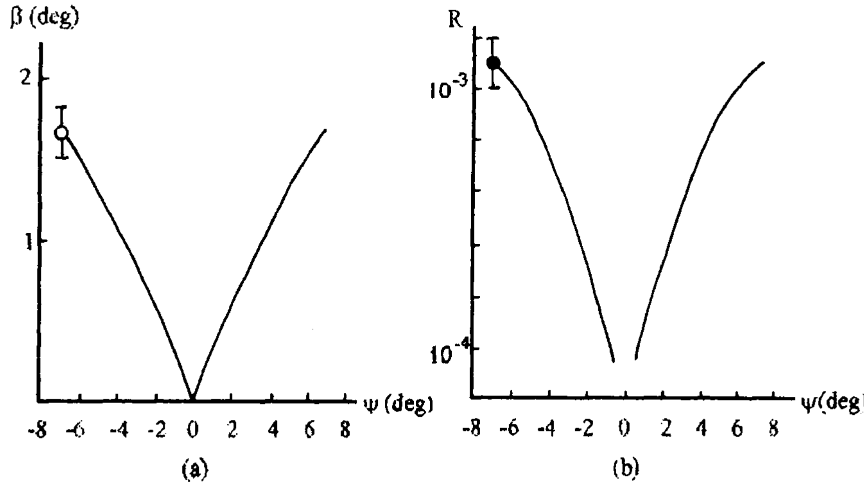

FIGURE 4 β - orientation of polarization plane in exit beam with respect to orientation in entrance beam (a) and R - extinction ratio (b) as a function of ψ and φ angles for planar orientation of NLC layer.

polarization plane orientation in entrance beam and orientation of polarization ellipse long axis in exit beam. The power of ellipticity is determined approximately by the extinction ratio shown in Figure 4(b). It can be seen from this figure that extinction ratio for planar orientation have no dependence on φ angle over the range of measurement accuracy. More detailed analysis of polarization state of transmitted beam for this orientation type will be reported later.

To compare the angular parameters of PLCPs with those of PBSs, it is necessary to determine the accordance between measured parameters. Angular dependence of extinction ratio and angular dependence of polarization plane position in our measurements correspond to transmission leakage and transmission coupling in Pezzaniti-Chipman experiments.

The main conclusions from comparision of our measurements and the measurement of these authors, are the following.

1. Both considered parameters for PLCPs and PBSs strongly depend on ψ angle and possess weak dependence (or have no dependence) on φ angle.
2. Over the invetigated ranges of angles the turning of polarization plane in exit beam of PLCPs approximately is equal to one of PBSs.
3. The extinction ratio for PLCPs in averidge is some times lower than for PBSs over the same angular ranges.

The comparision shows the advantage of PLCPs under the PBSs in extinction ratio value, especially in the angular region near normal incidence.

CONCLUSION

We have demonstrated the angular dependences of prism liquid crystal polarizers: the direction of polarization plane orientation in exit beam and the extinction ratio as the functions of angles that characterize the direction of incidence. The simple explanation of such angular behavior is given for homeotropic orientation and is pointed out to the necessity of more detailed consideration for planar NLC orientation. The comparison with angular parameters of PBSs shows the attraction of PLCPs applications in different optical devices.

REFERENCES

1. Y.Larry Pezzaniti and Russel A.Chipman, Applied Optics, 33, 1916 (1994).
2. A.A.Karetnikov and A.P.Kovshik, Mol.Cryst.Liq.Cryst., 263, 537 (1995).
3. Angus J.Tocher and Shin-Tson Wu, Mol.Cryst. Liq.Cryst., 263, 507 (1995).