APPLICATION OF THE STATISTICAL APPROACH TO THE PROCESS OF LIGHT SPREADING IN TWIST-STRUCTURES OF LYOTROPIC LIQUID CRYSTALS

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According to the adiabatic theorem [1] a direction of light polarization inside a layer of a liquid crystal (LC) remains parallel to the director, if it satisfies Mogen condition:

$$\theta\cdot\lambda << 2\pi\cdot\Delta n\cdot d, \qquad (1)$$

where λ - length of light wave; θ- maximal angle of the director deviation from an initial state at the centre of a LC layer; Δn - difference between ordinary and unordinary parameters of refraction, d - thickness of the LC layer. The performance of a condition (1) actually means that each director on ways of light beam represents by itself the analyzer. In this case, for twist-deformation the well-known expression of the Maluce law (in crossed on polarizers) is applicable:

$$I=I_0\cdot\sin^2(\delta/2)\cdot\sin^2[2\cdot\varphi(z)], \qquad (2)$$

where I_0 - intensity of light falling at LC, z - direction of light wave spreading (perpendicular to the surface of a LC layer), $\varphi(z)$ - angle between polarizer and director, δ - difference of phases between ordinary and unordinary beams of light. For many lyotropic nematics the condition (1) is not carried out because of small value of Δn [2]. Therefore even for values of magnetic field intensity H a little bit exceeding a field of Frederics threshold H_c the light field of the analyzer is clarified [3]. In this case using of the Maluce law in form of (2) results in the contradiction, i.e. it gives I=0 at the output of the analyzer. It is connected to the fact that here the expression (2) is not applicable because of infringement (1): each director can not any more carry out function of the analyzer on ways of light beam. The application of the Maluce law for twist-deformation is possible and in the case of infringement of a condition (1), if anyone at a choice of an angle in the formula (2) will be guided by the statistical approach. In the given situation we offer to consider interaction of light with nematic as with a monocrystal, optical indicatrisse of which is orientated on the average director. Thus, according to our approach the formula (2) should be changed to expression:

$$I=I_0\cdot\sin^2(\delta/2)\cdot\sin^2\langle 2\varphi(z)\rangle, \qquad (3)$$

where $\langle\varphi\rangle = \int_0^d [\varphi(z)]^2 dz \Big/ \int_0^d \varphi(z)dz$; (z) - function of distribution of the director on an axis z. As an illustration of applications of expression (3) we shall take a well-known ratio for LC deformation in a magnetic field [4]:

$$\varphi(z)=2\cdot[(H/H_C)-1]^{1/2}\cdot\sin(\pi z/d).$$

After substitution of this ratio in (3), we shall receive theoretical dependence $I(H)$:

$$I(H)=I_0\cdot\sin^2(\delta/2)\cdot\sin^2\{\pi\cdot[(H/H_C)-1]^{1/2}\}. \qquad (4)$$

At small angles $\varphi(z)$ ($[(H/H_C)-1]<<1$) dependence $I(H)$ becomes linear one. This fact qualitatively confirms the effect of an enlightenment of a light field of the analyzer observed in [3]. Besides, it is necessary to add, that the dependence $I(H)$, if it is received experimentally, allows to determine value of double beam refraction ($\Delta n=n_e-n_0$) of liquid crystals. It follows from dependence $\delta=(2\pi d/\lambda)\cdot\Delta n$ and from that fact, that Δn at twist-deformation does not depend on the value of a magnetic field.

References
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