Optical Vortex Generation Using Photoinduced Orientational Defects in Nematic Liquid Crystals

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***Abstract*— Optical vortices were generated by means of photoinduced point defects in orientation of the nematic liquid crystal (NLC). The axisymmetric distribution of NLC director field was produced due to photorefractive effect in NLC or due to isotropic channel formation in light absorbing NLC.**

Keywords*— *Nonlinear optics, optical vortices, liquid crystals.

Optical vortices are of interest due to their applications such as micromanipulation, optical data processing and transmission, etc. These beams belong to free space modes characterized by the presence of the orbital angular momentum and minimum intensity on the beam axis.

The nematic liquid crystals (NLCs) can be used for optical vortex generation [1]. NLCs are substantially anisotropic media the optical properties of which can easily be controlled by external fields, temperature, boundary conditions, etc. A point defect of orientation of the NLC director field is required to vortex beam formation. To this end, special treatment of substrates is usually used which leads to radially symmetric boundary conditions. There is a method for the optical vortex generation in the absence of a preliminary formed defect in which an NLC cell with photoconducting layer is required.

In this study, we proposed two methods of producing photoinduced defects in NLC orientation and generation of optical vortices (Fig. 1). In the first one, the photorefractive effect was used [2]. A dc electric field applied to homeotropic NLC is screened by near-surface charges. In the illuminated region, the screening partially removes and electric field penetrates the NLC bulk. This field reorients the NLC molecules (Fig. 1a) and causes axisymmetric deformation of the director field (Fig. 1c). In the second one, the dye doped NLC with homeotropic orientation was used [3]. Under the action of light the isotropic channel on the beam axis was formed due to heating. Axisymmetric director field is caused by NLC molecular orientation on the nematic–isotropic boundary (Fig. 1b).

When the circular-polarized Gaussian light beam passes through such structures, the beam with wavefront screw dislocation is generated. The handedness of vortex polarization is opposite to that of incident beam.

The transformation of the incident beam into the vortex beam is determined by phase shift δ between ordinary and extraordinary waves. The value δ depends on the distance from the light beam axis. Thus, in the considered cases, the transformation of the Gaussian beam into the singular one is only partial. This results in two components of the optical field upon the passage of the NLC, the Gaussian and the vortex ones. The combination of the quarter wave plate and the polarizer placed after NLC cell allowed us to separate components and also produce the interference pattern. The numerical calculations of diffraction patterns in the far field performed for each case are in a good agreement with the experiment.

References

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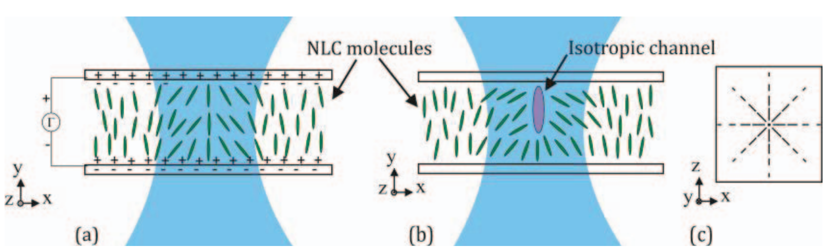

Fig. 1. Schematic distribution of the NLC molecule orientation (a) in the case of photorefractive effect and (b) in the case of isotropic channel formation in dye doped NLC; (c) the NLC director projection on the plane ZX.

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