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INTERACTION OF THE NARROW GAUSSIAN BEAM WITH VORTEX BEAM IN CUBIC OPTICALLY ACTIVE PHOTOREFRACTIVE CRYSTAL

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Optical vortices [1] which also call the singular [2] or vortex beams [3] represents an propagating light field with a zero intensity in center of cross section, and the phase shift at circumvention of such zero point is an integer multiple of 2π [1]. If to look in the direction parallel to an axis of propagation, the optical vortices looks as dark area in the center of a bright concentric ring of light [4]. Thanks to special properties of the singular beams connected with existence of the angular moment, various application of optical vortices, as for laser technologies (for example, for creation of optical tweezers [5]), and for medicine, microbiology, metrology, astronomy (for example, for creation of vortex coronagraphs [6]), etc. are known.

One of the most important applications of optical vortices as spatial solitons is their use for induction of waveguides [3] which can be applied in optical switching. In the defocusing media the optical vortices can form a soliton [7] when beam diffraction due of a dark core extending, is compensated by defocusing nonlinearity. Now generally the conditions of formation of an optical vortex soliton and its applications as the waveguide executed on the basis of a crystal of SBN [8] with applied external electric field are investigated.

In this work features of interaction of the narrow Gaussian beam with vortex beams of various signs of the topological charge in a cubic optically active photorefractive crystal BSO to which external electric field is applied are investigated.

For numerical modeling of interaction of singular [9] and Gaussian light beams in cubic photorefractive optically active crystal of a class 23 with the cut plane $(\bar{1}\bar{1}0)$ the system of the scalar differential equations in partial derivatives [10] is used. We will consider the case, when external electric field $\vec{E}_0$ is parallel to the crystallographic direction $[1\bar{1}\bar{1}]$.

For research of interaction of the singular optical beam with a radius of a background Gaussian beam [9] r = 80 mkm and the narrow Gaussian beam with a width x = 25 μm (see Figure 1) the parameters close to parameters of the crystal BSO: $n_0 = 2.54$, $r_{41} = 5\cdot10^{-12}$ m/V, ρ = 22 °/mm are used. Wavelength λ = 0.6328 μm.

In Figure 2,a_1,b_1 results of numerical modeling of interaction of the vortex beam with a topological charge m = 1 and the Gaussian beam in the cubic photorefractive crystal with applied external electric field E = -2.6 kV/cm taking into account the optical activity of the crystal are shown.

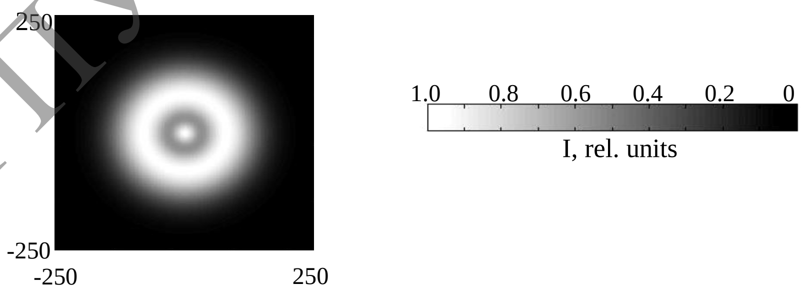

Fig. 1. Distribution of a light field of Gaussian and vortex beams at an entrance to the photorefractive crystal

The electric field is chosen so that the relative intensities in the center of the narrow Gaussian beam at entrance and exit of the crystal are practically coincided. Thereby an attempt of formation of a quasi-soliton mode of the Gaussian beam in the defocusing media using the vortex beam is made. As numerical calculations show (see Figure 2, a_2, b_2) "switching off" the optical activity under the same other conditions of interaction of the narrow Gaussian and vortex beams the relative intensity in the center of a Gaussian beam increases to 22.7%.

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In Figures 2,a_3,b_3 and 2,a_4,b_4 the results of numerical modeling of the interaction of the singular beam (a topological charge m = –1) with the narrow Gaussian beam are shown under the same remaining conditions of distribution in the photorefractive crystal thick 10 mm with and without taking into consideration the optical activity respectively.

It is visible from Figs. 2 2,a_3,b_3 that change of a sign of a topological charge from m = 1 (Fig. 2, a_1, ba_1) to m = –1 (Fig. 2, a_3, ba_3) leads to increase of the relative intensity in the center of the narrow Gaussian beam by 11.9%. Note that "the switching off" the optical activity at interaction of the narrow Gaussian beam with the vortex one at changing a topological charges from m = 1 to to m = –1 leads to increase in the relative intensity by 29.2%.

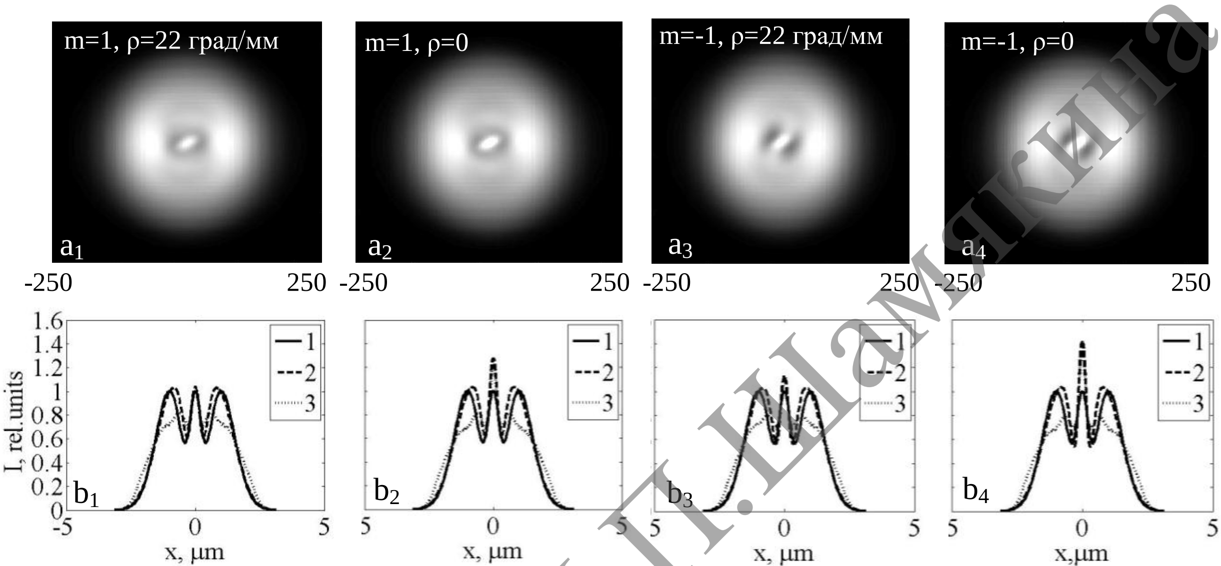

Fig. 2. Distribution of the light field of the narrow Gaussian and the vortex beams (a_1–a_4) and the cross profiles of the relative intensity ($б_1$–$б_4$) of the interacting beams in the photorefractive crystal of 10 mm thick. Curve 1 – the cross profiles of the light field at an entrance to the crystal, curves 2 and 3 – the x- and y-cross profiles at the exit from the crystal

Thus, by means of numerical modeling features of interaction of the narrow Gaussian beam with vortex beams for various signs of a topological charge in the cubic optically active photorefractive crystal with the external electric field applieded are investigated. It is established that at E = –2.6 kV/cm using the singular beam with a topological charge of m = 1 it is possible to create conditions of quasi-soliton propagation of the narrow Gaussian beam in the defocusing non-linear media. It is also shown that change of a sign of a topological charge from m = 1 to m = –1 and “switching off” the optical activity leads to increase in relative intensity of the Gaussian beam propagating into the singular beam in the defocusing nonlinear optical active photorefractive crystal.

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