THE FORMATION CONDITIONS OF OPTICAL SOLITONS IN THE OPTICAL ACTIVITY SILLENITE CRYSTALS

Dovhyj Ya.O., Zamorsky M.K., Man'kovska I.G.
Physics Department, Lviv Ivan Franko National University, Lviv, Ukraine
E-mail: dovgy@physics.wups.lviv.ua

The cubic optical activity sillenite crystals $Bi_{12}MO_{20}$ (M=Ge, Si, Ti) (enantiomorphous class 23) are characterized by high photorefractive optical nonlinearities. It allows to use these materials for the record of volume dynamic holograms [1] and in other systems for optical treatment of information [2-4]. We considered a new aspect of optics of photorefractive nonlinear sillenites – the possibility of the formation of optical soliton. Thus substantial attention was paid to consideration the influence of optical activity of these crystals [5].

Self-focusing of Gaussian beams and the formation of optical solitons in sillenite depend not only on the laser beam intensity I, the magnitudes and orientation of the electric vector of applied field $\boldsymbol{E}_0$, the electrooptical coefficient r_{41}, the unperturbed refractive index n_0, but also the rotatory power ρ at laser wavelength λ. For the geometry of experience, when the wave vector $\boldsymbol{k} \parallel \boldsymbol{z}$ and when the applied field is in the x-direction, the stable soliton can be formed on condition that this system of simultaneous normalized nonlinear equations is satisfied [6-7]:

$$i\frac{\partial u}{\partial z}+\frac{1}{2}\frac{\partial^2 u}{\partial x^2}-\eta\frac{\mu_1 u+\mu_2 v}{1+I}-v\Delta=0, \qquad i\frac{\partial v}{\partial z}+\frac{1}{2}\frac{\partial^2 v}{\partial x^2}-\eta\frac{\mu_2 u+\mu_3 v}{1+I}+u\Delta=0,$$

where u and v – dimensionless polarization parameters: u-component concern $\boldsymbol{E}\|\boldsymbol{x}$, and v-component – $\boldsymbol{E}\|\boldsymbol{y}$; $\eta=\frac{1}{2}\left(n_0^4 k^2 x_0^2 r_{41} E_0\right)$, $\Delta=n_0 k x_0^2 \rho$, $k=\frac{2\pi}{\lambda}$, x_0 – spatial half-width of TEM_{00}-mode, $\boldsymbol{E}$ – strength of light field, $\mu_1=3\sin\theta\cos^2\theta$, $\mu_2=\left(1-\sin^3\theta\right)\cos\theta$, $\mu_3=\left(1-3\cos^2\theta\right)\sin\theta$, θ – orientational angle.

Crystal	n_0	r_{41}, m/V	ρ, °/mm
$Bi_{12}GeO_{20}$	2,55	$3{,}4\times10^{-12}$	20,8
$Bi_{12}SiO_{20}$	2,54	$5{,}0\times10^{-12}$	21,8
$Bi_{12}TiO_{20}$	2,25	$6{,}2\times10^{-12}$	6,3

The considered soliton formation effect in the sillenites was observed by using low-power He-Ne lasers. For typical sillenite parameters (see Table) at λ = 0.6328 μm and x_0 = 20 μm the optimal conditions for soliton formation are $E_0 \cong 10^4$V/cm, $\theta \cong 35{,}3°$ (u-polarization). The optimization of parameters θ and E_0 depends on the ρ. The data in table are shown at He-Ne laser wavelength (λ = 632.8 nm).

References

[1] Shandarov S.M., Burimov N.I., Dubtsov M.A. et.al. *Laser Phys.*, 2007, **17**, 482.
[2] Kuhtarev N.V., Brodin M.S., Volkov V.I. *Phys.of the Sol.St.*, 1988, **30**, №9, 2757.
[3] Petrov M.P., Stepanov S.I., Homenko A.V. Photorefractive Crystals in coherent optics. SPb: Nauka, 1992. – 320 p.
[4] Photorefractive Materials and their Applications. Berlin: Springer-Verlag, 2007.
[5] Dovhyj Ya.O., Zamorsky M.K., Kityk I.V. *UPhJ*., 1989, **34**, №11, 1663.
[6] Kivshar Yu.S., Agrawal G.P. Optical Solitons. From Fibers to Photonic Crystals. San Diego: Academic Press, 2003.
[7] Shepelevich V.V., Golub A.A., Kovarshyk R.a.o.*Tech.Phys.Lett.*, 2004, **30**, №21, 49.