The influence of the physical properties of crystals on the noncollinear interaction of light waves in nonlinear media is examined in an example of LiIO$_3$ and K$_2$S$_2$O$_6$. Peculiarities in the vector interaction are noted in crystals with quadratic and cubic nonlinearities. Experimental results are presented.

An investigation of the non-collinear interaction of light waves in nonlinear crystals is of interest in connection with its extensive practical application [1-3]. Some peculiarities of vector interactions in KDP and ADP crystals have been examined earlier in [4, 5]. The frequency-angle characteristics of the vector interaction of light waves in crystals with quadratic (LiIO$_3$, K$_2$S$_2$O$_6$) and cubic (LiIO$_3$) nonlinearities are presented below.

**Vector Interactions in Crystals with Quadratic Nonlinearity**

Partial scattering of the collimated beam of laser radiation ($\kappa_1, \omega_1$) in a nonlinear crystal permits clarification of a number of vector-interaction peculiarities. The conditions of vector synchronization in a crystal for a given direction $\kappa_1$ can be satisfied for a set of directions $\kappa_2 (\omega_2 = \omega_1)$, and therefore also $\kappa_3 (\omega_3 = \omega_1 + \omega_2)$, forming a conical surface [5]. Presented in Fig. 1a is the distribution of radiation at a frequency $2 \omega_1$ in the plane of photographic film located at the distance $l = 19.5$ mm from a $L = 8.5$ mm long KDP crystal (incidence of a ruby laser beam ($\omega_1$) normal to the crystal surface, $\omega_0 \rightarrow e$ interaction). Radiation ($\omega_3$) in the form of a ring occurs in addition to the second harmonic excited outside of synchronization in the direction of intense pumping. The diameter of the reduced distribution ring is 11.3 mm.

**Fig. 1.** Distribution of radiation of the total frequency ($\omega_3$) in the near field (interaction $\omega_0 \rightarrow e$, $\lambda = 0.6943$ $\mu$). Crystals: a) KDP ($D \approx 11.3$ mm), b) LiIO$_3$ (plane of synchronization is lesser dimension of the "rings," the greatest diameter of the outer "ring" is $\sim 24.8$ mm).
If the angles $\varphi_1$, $\varphi_2$, $\varphi_3$ formed by the vectors $K_1$, $K_2$, $K_3$ with the optical axis are introduced, then the value of the ring diameter $D$ can easily be computed depending on the location of the scattering domain in the crystal:

$$D = 2 \left[ L' \lg |\varphi_c| \frac{|\eta_{\alpha}(\varphi_c) \sin |\varphi_c|}{1 - \eta_{\alpha}(\varphi_c) \sin^2 |\varphi_c|} \right],$$

where $L'$ and $t$ are the spacings between the exit face of the crystal and the scattering domain and the photographic film, respectively, $\varphi_c$ is the angle between $K_3$ and $K_1$ upon compliance with the synchronization condition (in the $\omega_0 \rightarrow e$ interaction case under consideration, $|\varphi_c| = 1/2 |\varphi_2 - \varphi_1|$, where $|\varphi_2 - \varphi_1|_C$ is the angle of vector synchronization), where

$$\cos \varphi_c = \frac{\eta_{\alpha}(\varphi_c)}{\eta_{\alpha_1}}.$$

Computation of $L'$ by means of the results of an experiment (Fig. 1a) shows that $L' = L$, from which the deduction can be made that sufficiently strong diffuse scattering of the radiation ($\omega_3$) resulting in the excitation of $\omega_3$ occurs on the forward surface of the crystal. Volume scattering (Rayleigh or Raman, for example) should also result in the appearance of radiation at a frequency $\omega_3$ because of the vector interactions, but as experiment showed, scattering in the volume is very much less than on the surface.

If the crystal is of sufficiently good quality, but there are local domains of inhomogeneity within, then additional rings appear. By measuring the diameters of these rings, we determine $L'$, i.e., the site of localization of these inhomogeneities in the crystal. Presented in Fig. 1b is the distribution of radiation with frequency $\omega_3$ obtained during propagation of ruby laser radiation normally to the optical axis of the LiIO$_3$ crystal under investigation ($L = 17$ mm, $\omega_0 \rightarrow e$ interaction). The outer ring corresponds to interaction between the incident radiation ($\omega_1$) and that scattered at the entrance surface of the crystal, while the two inner rings correspond to interaction with chips in the crystal. Some ellipticity in the rings is caused by the presence of great birefringence in the LiIO$_3$ crystal.

The radiation intensity at the total frequency ($\omega_1 + \omega_2 = 2\omega_3 \omega_0 \rightarrow e$) is $I_{\omega_3} \sim d_{\alpha_1\alpha_2}^2 \sin^2 \varphi_3$ in the plane of synchronization of the LiIO$_3$ crystal, and is a maximum when $K_3$ is normal to the optical axis ($d_{\alpha_1}$ is the component of nonlinear susceptibility). The intensity $I_{\omega_3} \sim d_{\alpha_1\alpha_2}^2 \cos^2 (\varphi_2 - \varphi_1)$ in the plane perpendicular to the plane of synchronization is a maximum for $\varphi_2 = \varphi_1$, which is possible only for ninety degree one-dimensional synchronization occurring for definite values of $\lambda$. The change in $|\varphi_2 - \varphi_1|_C$ as a function of $\varphi_3$ is presented in Fig. 2: curve 1 in the plane of one-dimensional synchronization, and 2 in the perpendicular plane (the angles $\varphi_1$, $\varphi_2$, $\varphi_3$ in this plane are measured from the crystallographic $x$ or $y$ axis).