Figure 1 shows the dependence of the yield of the reaction on t'. For comparison are shown also the results of [1]. Fitting by least squares shows that the distribution can be described by a sum of two exponentials. For $t' \geq 0.06$ $(GeV/c)^2$, the cross section plotted logarithmically as a function of t' has a slope $B_1 = 7$ $(GeV/c)^{-2}$, corresponding to πN interaction. The slope determining the behavior of the cross section at small values of t is $B_2 = (41.5 \pm 2.5)$ $(GeV/c)^{-2}$.

The character of the distribution shows that at primary pion momentum values ∿4 GeV/c there is still coherent production of the system $\pi^+2\pi^-$ on the nucleus. The coherent-reaction cross section per effective molecule of the freon mixture is $\sigma_0 = (5.6 \pm 2.7)$ mb/$C_2F_5Cl_3$, corresponding to a cross section per average nucleus ($\bar{A} = 22.5$)

$$\sigma_{nuc} = (0.07 \pm 0.03) A^{2/3} \text{ mb/nucleus}$$

The distribution with respect to the effective masses of the systems $\pi^+\pi^-$ and $\pi^-\pi^-$ for all chosen events are shown in Fig. 2. The character of these distributions is different. For the $\pi^+\pi^-$ system it has a concentration near the mass corresponding to the ρ-meson mass. There is no such grouping for the $\pi^-\pi^-$ distribution. Figure 3 shows the distribution with respect to the mass of three pions. If we choose the value of the $\pi^+\pi^-$-system mass in the interval 700 MeV $\leq M_{\pi\pi} \leq$ 830 MeV, then the corresponding distribution for $(\pi^+2\pi^-)$ becomes narrower and groups near the A_1-meson mass. It should be noted that the mass distributions obtained in the present paper hardly differ from the distributions for higher energies, when the fraction of the coherent reactions is much higher.

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EXPERIMENTAL OBSERVATION OF NONLINEAR OPTICAL ACTIVITY

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A theoretical analysis of the different mechanisms of nonlinear optical activity (NOA) has been carried out in a number of papers [1 - 6]. The nonlinear increment of the angle of rotation of the plane of polarization for the orientational and striction mechanisms is, according to the estimates of [2],

$$\Delta\theta \sim 10^{-12}[\alpha]\ell I, \quad (1)$$

where [α] is the specific rotation, ℓ the length of the region of nonlinear interaction, and I the intensity of the laser pulse; in the case of the thermal mechanism we have [6]

$$\Delta\theta^T \sim 10^{-3}[\alpha]\ell k_\omega \int_{-\infty}^{t} I(r)dr, \quad (2)$$

where k_ω is the light absorption coefficient. The possibility of varying $\Delta\theta^T$ over a wide range by varying k_ω is an advantage of the thermal mechanism of the NOA. In the present paper we present results of the first experimental observation and measurement of NOA in colored crystalline quartz and in one solution of L-cystine sulfate. The NOA effect observed by us is due to absorption of the energy from a light pulse emitted by a ruby laser in the free generation regime. The pulse energy was 20 - 30 J. The nonlinear angle of rotation of the plane of polarization $\Delta\theta^T$, due to the absorption [6], is determined in the case of a liquid by the coefficient of expansion and by the absorbed energy, and amounts according to estimates based on [2] to $\sim 10°$. For colored quartz $\Delta\theta^T \sim 40°$. The investigated quartz crystal was exposed to x-radiation, as a result of which it acquired a dark brown color, and the solution of the L-cystine was colored with copper sulfate. The experimental setup is shown in Fig. 1. Light from the pulsed laser was focused by a cylindrical lens L into the optically active sample V. The sample was illuminated in a perpendicular direction by a broad beam of linearly-polarized light from an He-Cd laser at $\lambda = 4416$ Å (in the case of the crystal - along the optical axis). A Glan prism (g_2) was placed behind the Corneille-Pratt prism [7] (K-P). The system of bands[1] was focused on the film of a high-speed camera (C).

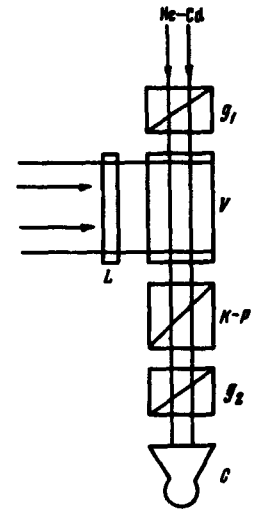

Fig. 1. Experimental setup. L - cylindrical lens, V - investigated optically-active sample, K-P - Corneille-Pratt prism, g_1, g_2 - Glan prisms, C - high-speed motion picture camera SK-1.

Figure 2a shows the characteristic change of the curvature of the bands, obtained in colored quartz. Measurement of the shift of the bands (2a 2, 2a 3, 2a 4) makes it possible to determine the change of the angular rotation of the plane of polarization as a function of the time (Fig. 3) and to calculate the temperature of the focal region. The characteristic temperature-equalization time, determined from the plot of Fig. 3, is $\sim 10^{-2}$ sec, which coincides in order of magnitude with the temperature relaxation time, determined by the thermal conductivity equation $\tau = \rho C a^2/\kappa \sim 10^{-2}$ sec, where ρ is the density, C the specific heat, a a characteristic linear dimension, and κ the coefficient of thermal conductivity. This points to a thermal character of the observed nonlinearity. The change of the angular rotation of the plane of polarization directly after passage of the ruby laser pulse, Fig. 2a 2, was $\Delta\theta^T = 42 \pm 7°$ at an initial $\theta_0 = 450°$, corresponding to heating of the sample by 475°C. As seen from Fig. 2, practically no thermal defocusing of the trial beam was observed in crystalline quartz. In the liquid (Fig. 2b), to the contrary, the thermal defocusing suppresses the NOA phenomenon. As seen from Fig. 2b 2, directly after passage of the ruby-laser pulse the light of the trial beam leaves the

[1] The Corneille-Pratt prism [7] is made of left-hand and right-hand quartz (Fig. 1), and therefore in the case of incident linearly-polarized light, a system of bands will be observed past the polarizer g_2 (Fig. 1). The position of the system of bands is determined only by the direction of the oscillations of the electric vector of the light wave. The rotation of the vector E leads to a displacement of the bands. Depolarization of the light only changes the contrast of the bands.

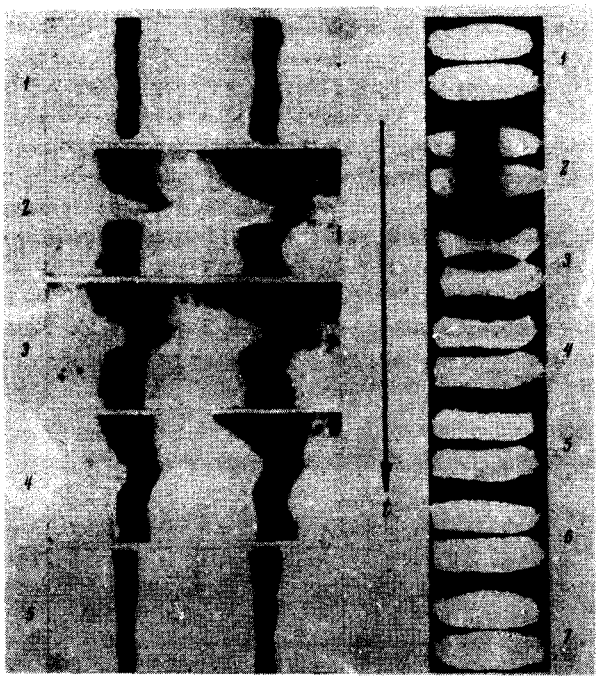

Fig. 2. Photographs of the bands past the analyzer. 2a) Crystalline quartz. 1 - Prior to the pulse of the ruby laser, 2 - $t_2 = 1.3 \times 10^{-3}$ sec after the pulse, 3 - $t_3 = 2.6 \times 10^{-3}$ sec; 4 - $t_4 = 10^{-2}$ sec; 5 - $t_5 = 10^{-2}$ sec. 2b) Aqueous solution of L-cystine sulfate: 1 - prior to the ruby laser pulse; 2 - $t_2 = 5 \times 10^{-2}$ sec; 3 - $t_3 = 6 \times 10^{-1}$ sec; 4 - $t_4 = 1.35$ sec; 5 - $t_5 = 2.2$ sec; 6 - $t_6 = 3$ sec; 7 - $t_7 = 5$ sec.

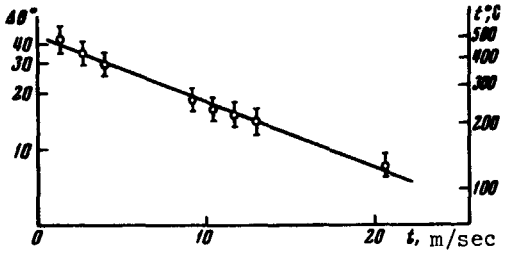

Fig. 3. Ordinates: right - temperature in logarithmic scale, left - corresponding change of angle of rotation of the plane of polarization in crystalline quartz. Abscissas - time.

focal region as a result of defocusing. Bending of the bands is observed only in subsequent instants of time (Figs. 2b 3, 2b 4, and 2b 5). Thus, in the case of a liquid, one can speak only of qualitative agreement between the observed effect and the calculation of [6].

The strong defocusing of the trial beam can, generally speaking, lead to a bending of the observed bands. Experimental proof that the influence of defocusing is small was obtained by rotating the Corneille-Pratt prism through 180°. Then, in the case of the NOA the sign of the band curvature is reversed, whereas the possible influence of the defocusing is invariant against such a rotation. These control experiments show that bending of the bands as a result of thermal defocusing is nonexistent in quartz and is small compared with the NOA effect in the liquid.

Obviously, the registration procedure proposed in the present paper can be used, with a suitable choice of the time-scanned scale, to measure the NOA due to electrostriction, orientational [2], and other mechanisms [1 - 6].

The self-action of the light as the result of the NOA can be used to obtain amplitude modulation of powerful light pulses. Estimates show that at helium temperatures the thermal mechanism in quartz can be used to obtain subnanosecond modulation of a giant pulse. Shorter pulses can be obtained with the NOA due to excitation inside the molecular degrees of freedom [3], and also by the orientational mechanism [2].

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DESTRUCTION OF TRANSPARENT DIELECTRICS BY LASER RADIATION

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It has by now been well established experimentally that the phenomenon of destruction of transparent dielectrics by laser pulses of duration $\tau \sim 5 \times 10^{-8}$ sec has a clearly pronounced threshold character with respect to the radiation intensity I. This effect can be explained with a minimum of contradictions by using the mechanism of electric breakdown in the optical field of the laser beam [1]. However, the final stage of optical destruction of transparent dielectrics is connected with local release of a sufficiently large amount of heat. From this point of view, it is interesting to consider one more destruction mechanism, or more accurately its initial stage, connected with the occurrence of electronic excitations as a result of the absorption of laser light by the matter, and the subsequent conversion of the excitations into heat. Insofar as the authors know, the role of bound electron-excited states has never been considered in the theory of optical destruction.

We shall assume that the laser light is absorbed by certain impurity centers [2], although the analysis presented below remains valid, in principle, also if the electron states of the dielectric itself are excited as a result of multiphoton absorption [1][1)]. The electron excitation produced on some center can vanish either by radiation or in nonradiative fashion with rate constants ν_R and ν respectively. Here $\nu_R = \nu_{RS} + \sigma I/\varepsilon$, where ν_{RS} is the probability of spontaneous radiation of a photon with energy ε; σ is the absorption cross section of this photon; I is the power flux density of the laser radiation, in units of energy/cm^{2}sec. Usually ν_R depends little on the temperature T, whereas ν has a strong dependence on it [3]. Near a certain temperature T_0 we can represent the experimental dependence of the constant ν on T in the form [3]

$$\nu(T) = B\exp(CT), \tag{1}$$

where B and C are constants. We note that the concept of local temperature used below and in formula (1), is meaningful when the inequality $\nu \leq 1/\tau_{vib}$ is satisfied, where $\tau_{vib} \sim 10^{-11} - 10^{-12}$ sec is the characteristic relaxation time of the vibrational energy in the solid phase.

[1)] Usually the energy of the laser photon is much lower than the energy of the electron-excited state of transparent dielectrics. Therefore the occurrence of electron excitations can take place here only as a result of the multiphoton process, which is the most probable in the case of self-focusing [1].