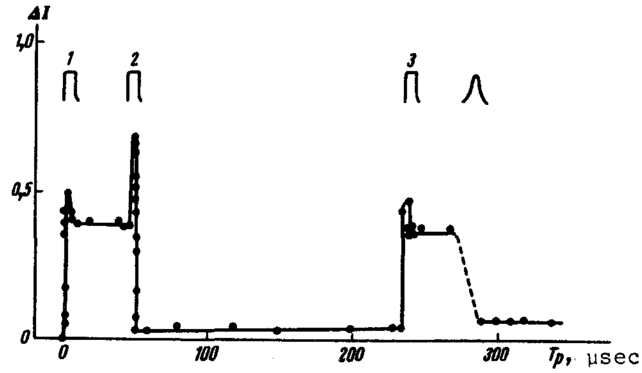

Fig. 3. Intensity of the effect ΔI/I for stimulated echo vs. the position of the microwave pulse.

microwave pulse is applied within this time interval. This conclusion turns out in full agreement with the experimental check (Fig. 3). It was established in the experiment that the intensity of the stimulated echo remains practically unchanged ($\Delta I/I \approx 0$) when the microwave pulse is located between the second and third radio-frequency pulses. At the same time, the effect exists ($\Delta I/I \neq 0$) at other values of T_p.

Besides the described phenomena, we investigated also the dependence of the effect ΔI/I on the microwave-pulse power and on the magnitude of the wave vector of the parametric spin waves. It was established that ΔI/I increases with increasing power after the instability threshold is reached, and also increases with decreasing K.

The observed effects can be used to investigate the state beyond threshold in a magnetically-ordered crystal, to determine the damping parameters of spin waves, to study electron-nuclear interactions, to observe the dynamics of motion of nuclear magnetization, and also to suppress crossover echo signal in multipulse experiments.

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THERMAL SELF-FOCUSING AND BREAKDOWN INDUCED IN NaCl, KBr, AND CsI CRYSTALS BY CO_2-LASER RADIATION

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We report in this article an effect obtained for the first time, that of thermal self-focusing at 10 μ wavelength and breakdown of crystals transparent in the infrared, induced by radiation from a pulsed CO_2 laser. It was observed that when the crystals NaCl, KBr, and CsI are exposed to focused strong radiation from a pulsed CO_2 laser, two types of breakdown occur in the interior of the crystal (electric and thermal). In the case of electric breakdown, a focal region is traced out in the crystal, and its length is larger by one order of magnitude than the value given by geometric-optics calculations. When powerful thermal breakdown sets in, a rather rapid displacement of the breakdown point, in a direction opposite that of the radiation, is observed. The magnitude of the displacement is comparable with the visible focal length obtained in electric breakdown. When the power is increased, the trace in the focal region breaks up into several (up to four) thin glowing strips with a total thickness ~1 mm.

The thermal self-focusing and defocusing have been investigated in sufficient detail in gases and in liquids [1 - 3]. External thermal self-focusing in crystals at $dn/dT < 0$ was observed in [4].

The crystals NaCl, KBr, and CsI are of interest because they are transparent in the 10-μ region and have $dn/dT < 0$. In the case of a homogeneous beam passing through a medium with $dn/dT < 0$, only thermal defocusing is possible. If the radiation-beam intensity near the axis is smaller than that near the edges, then the so-called "banana" self-focusing [2, 3] is possible if $dn/dT < 0$.

According to [1, 2], heating of the medium following absorption of radiation produces a change in the refractive index

$$\delta n_T = n_{2T} E^2 = (\alpha c E^2 / 4\pi C\rho)(dn/dT)\tau ,$$

where α is the absorption coefficient, c the speed of light, C the specific heat, and ρ the density of the medium. For NaCl we have $dn/dT = 2.2 \times 10^{-5}$, $\alpha = 4 \times 10^{-4}$ cm^{-1}, $C = 2 \times 10^{-1}$ J-g/deg, and $\rho = 2.17$ g/cm^3. At these values we get $n_{2T} = 5 \times 10^{-6}\tau$. If the radiation pulse duration τ is several hundred nsec, the resultant contribution is comparable with that of the Kerr effects in liquids in which self-focusing of ruby-laser radiation is observed ($n_2 \simeq 10^{-11}$ cgs esu).

In our investigations, we focused into the NaCl, KBr, and CsI crystals radiation with $\lambda = 10.6$ μ obtained from a double-modulation CO_2 laser [5] consisting of a two-meter master generator and three amplifiers with total length 8 m. At radiation pulse durations from 100 to 250 nsec, the peak power reached 200 kW. The pulse repetition frequency amounted to 50 Hz. The transverse cross section of the laser beam had the shape of a ring with outside diameter ~50 mm and inside diameter ~35 mm. The beam was focused into the interior of the investigated crystals with a salt lens of focal length f = 100 mm. At a laser-beam divergence $\phi = 5 \times 10^{-3}$ rad, the length of the focal region should

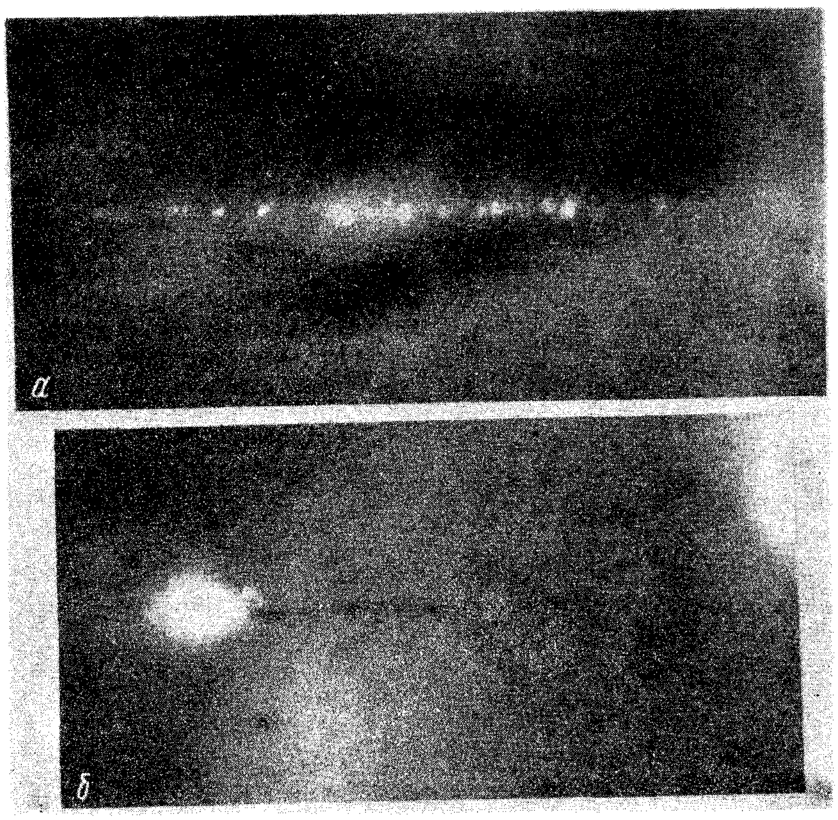

Fig. 1. Picture of breakdown in NaCl crystal. The faser radiation propagates from left to right. Filament length 2 cm; a - electric breakdown, b - thermal breakdown.

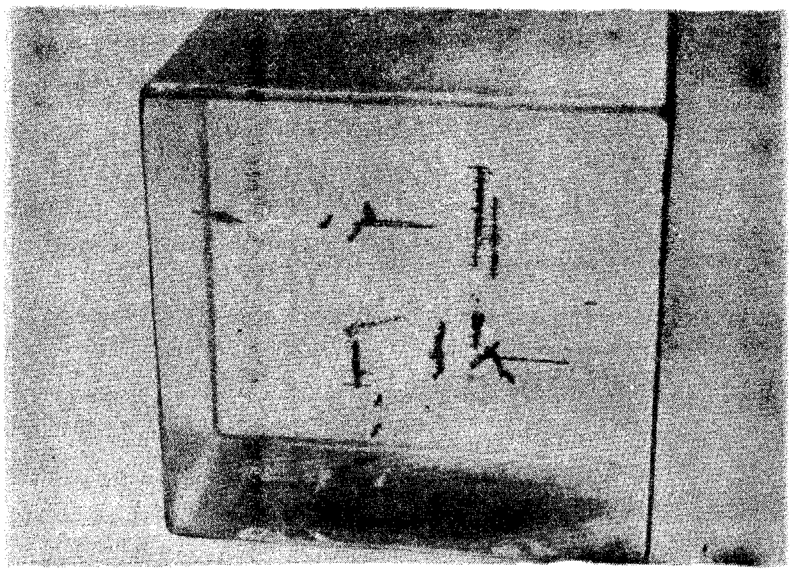

Fig. 2. Damage produced in NaCl crystal by self-focusing.

be $z = \phi f/h = 2$ mm, where $h = 25$ mm is the radius of the focused beam. However, when the focused radiation passed through the crystals, we observed a sparking trace in the form of a thin filament up to 20 mm long. Figure 1a, obtained with an exposure of 0.5 sec, shows about 25 bright spots, each of which corresponds to electric breakdown inside the crystal. In [6], where self-focusing of ruby-laser radiation was produced in glass by a mechanism of the Kerr type, the appearance of several bright spots was observed during the course of one rectangular pulse. The picture of the pointlike faults obtained in [6] was associated with a discrete multifocus model of self-focusing [7]. Unlike in [6], in our case the samples were exposed to a continuous sequence of bell-shaped pulses, and each bright spot corresponds to one pulse of CO_2-laser radiation.

After several seconds, a bright flash is produced at one of the points. This flash is much more powerful than in electric breakdown, and moves slowly, in a time on the order of seconds, in a direction opposite that of the radiation (towards the lens, Fig. 1b). We attribute this phenomenon to thermal breakdown in the crystal. Indeed, it follows from [8] that the electric field intensity required for electric breakdown in NaCl is 1.5×10^6 V/cm, whereas the intensity required for thermal breakdown, which sets in when the temperature of the medium is increased to 200°C, is 10^4 V/cm. For KBr and CsI, the breakdown voltages are much lower, as is indeed observed in our experiment. Notice should be taken of the characteristic behavior of the residual phenomena after the breakdown. In the NaCl crystals the damage tracks are black in color, whereas in KBr and CsI they are blue. The damage points are surrounded by brilliant lobes. Figure 2 shows a photograph of a NaCl cube damaged by radiation focused in the direction of different faces.

The threshold for damage of NaCl crystals by radiation from a powerful ruby laser with pulse duration ~7 nsec, was determined in [9]. This threshold sets in at a radiation density $\sim 2 \times 10^9$ W/cm^2, corresponding to a field intensity 1.5×10^6 V/cm. This allows us to conclude that in our case the beam diameter in the focal region (Fig. 1) did not exceed 10^{-2} cm, which can be the result only of self-focusing.

When the pulse radiation is decreased to 50 nsec (and consequently, when the power is increased), the beam breaks up in the focal region into several glowing strips. This phenomenon can be explained on the basis of the results of [10, 11], where it is shown that when the critical power is greatly exceeded the self-focusing beam breaks up into individual thinner beams as a result of the inhomogeneity of the wave front.

Thus, irradiation and breakdown of crystals that are transparent in the infrared region by means of a powerful pulse from a CO_2 laser has made it possible to observe directly thermal self-focusing of 10-μ radiation in solids having $dn/dT < 0$.

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BOSE-EINSTEIN CONDENSATION OF EXCITONS IN A CdSe CRYSTAL

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The purpose of this investigation was an experimental search for the phenomenon of Bose condensation of excitons.[1)]

The CdSe crystal was chosen because the excitons in it are predominantly repelled from one another [2], and not attracted, and this, as is well known [1, 3], is the condition for Bose condensation of excitons.

The authors have focused their attention on the emission spectrum of CdSe in the LO band of intereaction of the excitons with the optical phonons [4]. As was noted by one of the authors[2)], this band can serve as a good indication of the onset of the Bose condensation of excitons, owing to the appearance of a narrow line (peak) on the long-wave boundary of this band, due to the vanishing of the momentum of the excitons following the Bose condensation.

The investigations were carried out at 4.2°K. The excitation source was the second harmonic of neodymium laser (λ_{exc} = 5300 Å). The pulse duration

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1)A detailed bibliography on Bose-Einstein condensation of excitons is given in Moskalenko's monograph [1].

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