relaxation proceeds via the paramagnetic impurity. On the other hand, the relaxation rate for the Tm nuclei changes very strongly with temperature in the 2 - 4.2°K range, and is descreibed by a relation of the type (solid curve in the figure):

$$T_1^{-1}(\text{sec}^{-1}) = 0{,}7\,T + 2\cdot 10^{-3}T^9 + 1{,}76\cdot 10^8 \exp\left(-\frac{1{,}44\cdot 32}{T}\right).$$

The third term in this expression corresponds to the relaxation process via an intermediate level with an energy interval $\Delta = 32$ cm^{-1}, well known for the Tm^{3+} ion in TmES from other measurements [6]; for the Er^{3+} ions in the ethylsulfate lattice we have $\Delta \approx 45$ cm^{-1}.

It is obvious that the relaxation of the Tm^{169} nuclei in ethylsulfate of thulium proceeds in the main not throug the Er^{3+} impurity ions, but through the proper 4f shell of the Tm^{3+} ion. Such a temperature dependence of the spin-lattice relaxation in NMR has apparently been observed here for the first time.

The authors thank I. N. Kurkin for measurements of the relaxation times of the Er^{3+} ions in TmES.

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CARRIER DRAGGING IN A SOLID UNDER THE INFLUENCE OF LASER EMISSION

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Submitted 19 November 1968
ZhETF Pis. Red. 9, No. 1, 49 - 52 (5 January 1969)

1. It is known that when photons are absorbed in a medium containing free carriers, the photon momentum is transferred to these carriers, and this leads to the appearance of an electric current. In a bounded crystal, this results in an electric field parallel to the Poynting vector of the electromagnetic wave, hindering the displacement of the carriers [1,2]. To observe this effect, we undertook a study of the longitudinal electric field that appears in CdS single crystals under the influence of laser light.

2. The CdS crystal was illuminated along the x axis by a light pulse from a Q-switched ruby laser. The pulse duration was about 35 nsec; the light intensity could be raised by focusing to 150 MW/cm^2. The CdS single crystals, which had a darc conductivity $\sim 10^{-8}$ ohm^{-1}cm^{-1}, were in the form of parallelepipeds with well-polished faces measuring 10 x 3 x 2 mm. The crystal was placed in a screened rotating chamber and had eight ohmic contacts connected in two groups near each end (Fig. 1a). Such an arrangement and connection of the contacts eliminates almost completely the potential difference due to the dc-effect [3] and its influence on the free carriers and other transverse effects. Special screens guarded the contacts against

the direct action of the laser radiation. The maximum value of the potential difference in the direction of the light propagation, and the waveform of the voltage pulse, were registered with a long-persistence oscilloscope.

3. A typical oscillogram of the signal, in the case of high laser-emission intensity ($\sim$10 MW/cm^2) is shown in Fig. 1b. The voltage pulse has a steep front, $\sim$15 nsec, and falls off with a characteristic time on the order of one microsecond. The sign of the effect corresponds to the appearance of a negative charge on the rear face of the crsytal. When the crystal is rotated 180° about the optical axis, the charge appears again on the rear face. This experiment was purposefully made to show that the occurrence of a longitudinal potential difference is not connected with the appearance of photo-emf due to the inhomogeneity of the crystal (crystals with negligibe photo-emf were chosen for the investigation).

Figure 2 (upper curve) shows the dependence of the maximum value of the longitudinal potential difference on the angle between the optic axis of the crystal and the electric vector of the light. We see that the signal has no angular dependence within the experimental accuracy.

A typical plot of the signal amplitude against the light-wave power is shown in Fig. 3. The curve consists of several sections. In the first section, $W < W_1$, where $W_1 \approx 25$ MW/cm^2, the signal differs from that at higher powers not only quantitatively but also qualitatively. The signal duration in the first section is about 30 - 40 nsec and has an angular dependence (Fig. 2, dashed curve).

When $W > W_2$ (Fig. 3), where $W_2 \approx 100$ MW/cm^2, a second kink is observed, at which the signal amplitude decreases.

4. The occurrence of the first section on the curve of Fig. 3 is apparently due to the influence of the field

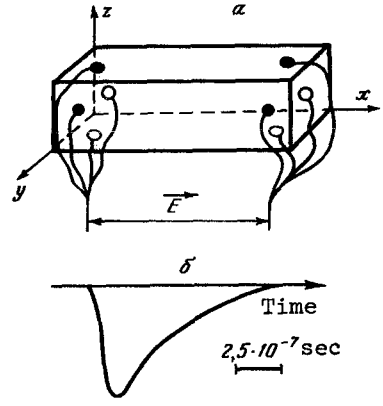

Fig. 1. Experimental setup. The optic axis of the crystal coincides with the z adis, the light propagates along the x axis. The dark and light circles denote the contacts. $\vec{E}$ - longitudinal electric field produced when the crystal is illuminated with a laser pulse; b - waveform of voltage pulse at a radiation power W = 100 MW/cm^2

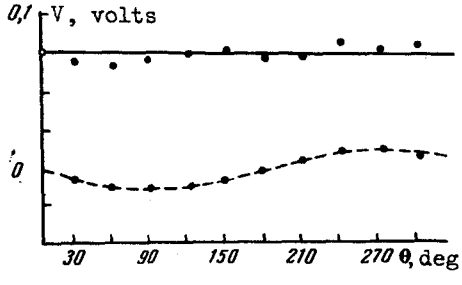

Fig. 2. Angular dependences of longitudinal potential difference. θ - angle between optic axis of crystal and electric vector of light. Upper curve - W ≈ 60 MW/cm^2, lower - W < 25 MW/cm^2 and its vertical scale is enlarged 10 times.

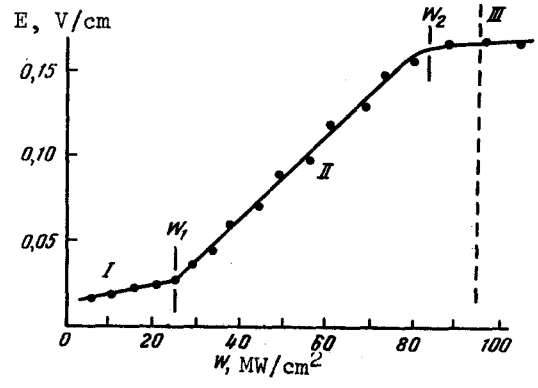

Fig. 3. Longitudinal electric field vs. laser-emission power. The vertical dashed line denotes the crystal damage threshold.

of the dc-effect on the free carriers. The electric field of the dc-effect can appear, in spite of the precautions, as a result of a slight asymmetry of the contact or a slight deviation of the laser beam axis from the crystal x-axis direction.

The main effect (sections II and III on the curve of Fig. 3) has a clearly pronounced threshold. It can be assumed that it is due to the dragging of the free electrons of the crystal, resulting from the action of the light wave. Favoring this hypothesis is the sign of the effect, which corresponds to dragging of electrons to the rear face, and the inflection on the curve of Fig. 3 at $W = W_2$. The value of W_2 corresponds approximately to the light intensity at which creation of electron-hole pairs as a result of two-photon processes yields a number of carriers of the same order of magnitude as that due to one-photon processes [4]. As is well known [2], a dragging of carriers of both polarities leads to a smaller effect than dragging of carriers of one sign. We note that the proportionality of the maximum value of the signal to the distance between contacts in the direction of any of the crystal axes also offers evidence of the volume character of the effect.

However, the effect observed by us cannot be attributed to simple dragging of the carriers in the case of bremsstrahlung processes [1, 2]. First, an estimate of this effect using the formulas of [2] leads to values that are lower by at least three orders of magnitude; second, the voltage pulse in the case of [2] should duplicate the form of the laser pulse. Third, the presence of a threshold of about 25 MW/cm^2 for the start of this process is an argument against the direct transfer of momentum from the photon to the electron subsystem (as is well known, the process of direct momentum transfer in photon absorption has no threshold).

In our opinion, the effect can be explained by assuming that the photon absorption in the solid is accompanied by the appearance of a directed stream of phonons, which in turn drags the electorns. In this case the duration of the observed pulse will be determined by the relaxation time of the generated phonons, the concentration of the free carriers produced by the light, etc. At the present time some of these quantities are still unknown, but it can be stated that a pulse duration of about 1 microsecond does not contradict the measured relaxation times of the hypersound phonons in CdS [5, 6].

We know that similar investigations of a laser-spark plasma containing approximately the same free-electron concentration as in our case, points to the absence of a dragging effect, accurate to 10^{-3} V/cm.

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