$$t_0 \sim \frac{(\Delta v_\parallel)^2}{D} \sim \tau \frac{16\pi N m u_0^2}{\sum_k |E_k|^2 \frac{\omega_0^2}{(\omega_k \mp \omega_p)^2}}, \qquad (8)$$

i.e., $t_0 > \tau$ within the limits of applicability of the present theory.

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[1)] The possibility of reducing the quasilinear equation for f to one-dimensional form in the case of cyclotron instability was indicated earlier in [5].

EFFECT OF HARD RADIATION ON THE OPTICAL CENTERS OF TR^{3+} IONS IN CRYSTALS

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We have observed a new effect produced by hard radiation in crystals with TR^{3+} impurity, consisting in a change of the structure and of the optical properties of the TR^{3+} centers.

It is well known that crystals containing trivalent rare-earth impurities (TR^{3+}) become colored under the influence of hard radiation such as γ rays, neutrons, deuterons, or fast electrons. However, the accompanying absorption (and sometimes luminescence) is connected either with the formation of proper color centers, or with a transition of the TR^{3+} to a divalent state [1-4].

The investigations were carried out with the crystals CaF_2:Nd^{3+} (0.3 wt.%), CaF_2:Er^{3+} (0.3 wt.%), and CaF_2:Eu^{3+} (0.3 wt.%, type I), synthesized by the procedure described in [5]. Figure 1a shows the absorption spectrum of the CaF_2:Nd^{3+} (0.3 wt.%) obtained at 77°K with a DFS-12 diffraction spectrometer. The spectrum corresponds to the transition $^4I_{9/2} \rightarrow {}^4F_{3/2}$. The letters L on the figure denote the lines belonging to tetragonal-symmetry centers, while M and N denote lines belonging to the two types of rhombic centers [6]. Figure 1b shows the

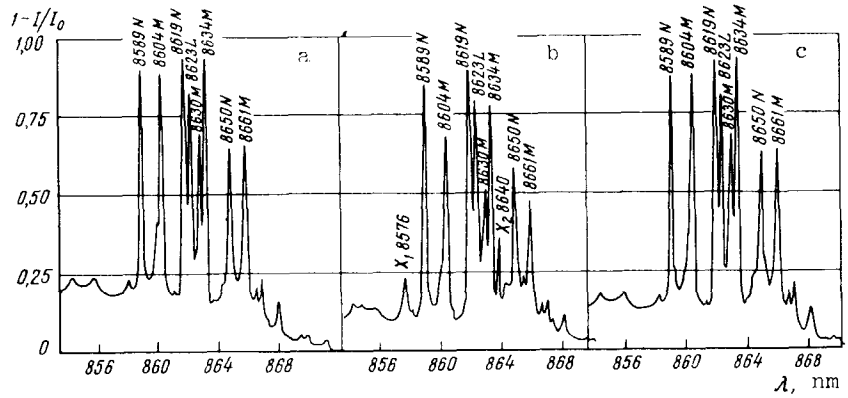

Fig. 1. Absorption spectrum of CaF_2:Nd^{3+}, 0.3 wt.%, at 77°K (transition $^4I_{9/2} \rightarrow {}^4F_{3/2}$): a - prior to irradiation, b - after irradiation with γ rays from Co^{60} (1.25 MeV), dose 10^7 r; c - after heating the irradiated crystal for one hour at 300°C.

absorption spectrum of the same crystal after irradiation with γ rays from Co^{60} (1.25 MeV, dose 10^7 r). It is seen from the figure that irradiation has greatly reduced the intensities of some lines and has also given rise to new lines (8576 and 8640 Å). The table lists the ratios of the absorption coefficients at the line maxima before and after irradiation. It is easily seen from a comparison of these values that: (i) the lines comprising a single system are decreased in like fashion, and (ii) the decrease is strongest in the M-system lines, less pronounced in the N system, and practically nil in the L system. The initial spectrum is completely restored after heating the irradiated crystal for an hour at 250 - 300°C (Fig. 1c).

CaF_2 : Nd^{3+}				CaF_2 : Er^{3+}			CaF_2 : Eu^{3+}		
Type	λ, Å	K_{irrad}/K_{init}	K_{rest}/K_{init}	Type	λ, Å	K_{irrad}/K_{init}	Type	λ, Å	K_{irrad}/K_{init}
N	8589	0.99	1.00	L	4460	1.08	L	5241.4	0.89
M	8604	0.59	1.00	N	4461	0.51	M	5253.4	0.75
N	8619	0.94	0.99	M	4464.5	0.66	L	5255	0.93
L	8623	1.01	1.01	L	4465.4	1.10	M	5255.9	0.70
M	8630	0.66	1.03	L	4468	1.05	M	5256.8	0.56
M	8634	0.61	1.02	L	4469.6	0.96	N*	5257.7	0.83
N	8650	0.93	1.01	M, N	4473	0.79	N*	5258.7	1.16
M	8661	0.61	1.02	L	4475.4	1.08	M	5260.2	0.68
L	8683	0.92	1.06	P	4478.9	0.39			
				P	4489.7	0.42			
				P	4492.5	0.62			

* Superposition of other lines makes the analysis inaccurate

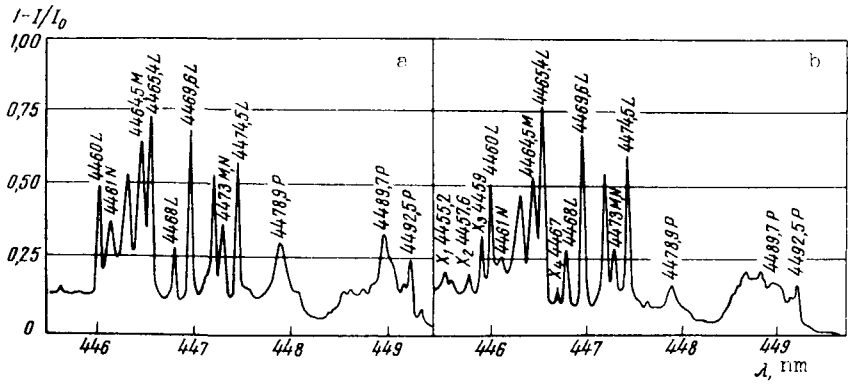

Fig. 2. Absorption spectrum of $CaF_2:Er^{3+}$ crystal, 0.3 wt.%, at 77°K (transition $^4I_{15/2} \rightarrow {}^4S_{3/2}$): a - prior to irradiation; b - after γ irradiation (1.25 MeV, 10^7 r).

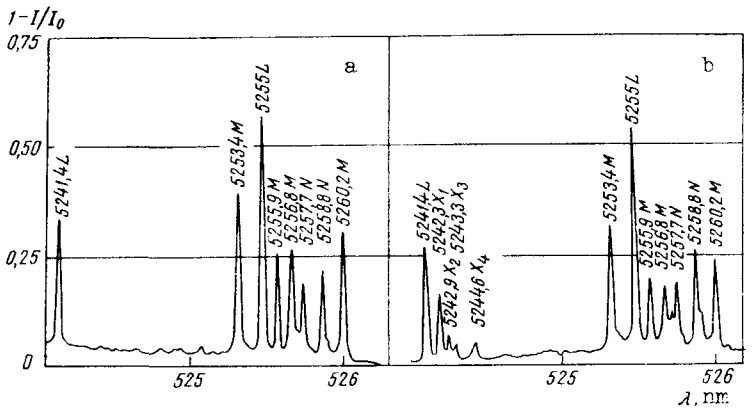

Fig. 3. Absorption spectrum of $CaF_2:Eu^{3+}$ crystal, 0.3 wt.%, at 77°K (transition $^7F_0 \rightarrow {}^5D_1$): a - prior to irradiation; b - after γ irradiation (1.25 MeV, 10^7 r).

Figures 2 and 3 and the table show analogous data for the $CaF_2:Er^{3+}$ and $CaF_2:Eu^{3+}$ (both 0.3 wt.%). It is seen that the character of the changes in the absorption spectra of these crystals is in principle the same as for $CaF_2:Nd^{3+}$ (0.3 wt.%). The initial spectrum is restored on heating to 300°C, the same as in the crystals with the Nd^{3+}.

Thus, comparing the obtained data, we can conclude that γ irradiation changes the structure of the optical TR^{3+} centers: some centers (M and N) disintegrate and are replaced by others, with a structure still unknown. Two mechanisms of TR^{3+}-center transformation are possible:

1. Ionic mechanism. This mechanism presupposes dissociation of the centers, i.e., their destruction. Dissociation causes the number of the M and N centers to decrease, while the TR^{3+} ions contained in them are already in other electric fields and their optical properties differ accordingly from the initial ones. Such a mechanism readily explains why the number of absorption centers of lower symmetry decreases, and there are now tetragonal-symmetry centers. It is known [7] that lower-symmetry centers have a more complicated struc-

ture, and incorporate several TR^{3+} ions and interstitial fluorine ions. The binding energies of these ions are lower than in the simpler-structure tetragonal centers. It is clear that the probability of destruction of more complicated centers is higher than that of the simpler ones.

2. Electron-hole mechanism. As a result of intense internal ionization accompanying the γ irradiation, a large number of electrons and holes are localized at various localization levels. In the case when the localization of the electrons or of the holes takes place sufficiently close to the TR^{3+} ion, the symmetry of its crystalline field changes, which is tantamount to formation of a center of a new type. This mechanism explains well the temperature instability of the crystal state produced following the irradiation, and the restoration of the initial structure of the centers. It is still unclear which of these mechanisms predominates.

It must be noted in conclusion that the effect observed in this investigation can be used for an analysis of the optical TR^{3+} centers in crystals by observing the inhomogeneous change in the absorption-line intensity following irradiation.

In addition, a study of the optical properties of the TR^{3+} centers in irradiated crystals can yield valuable information on the character of the processes which occur when hard radiation interacts with crystalline matter.

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IONIZATION OF AN ATOM COLLIDING WITH AN EXCITED ATOM

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1. In this paper we calculate the cross section of the reaction

$$A^* + B \to A + B^+ + e, \qquad (1)$$

with the excitation potential of atom A exceeding the ionization potential I of atom B. The assumption is used that the cross section of transition (1) is determined essentially by collision impact parameters which greatly exceed the dimensions of the colliding atoms. Transition (1) is an important process occurring in the gas discharge of a gas laser [1-3]. If the atom A^* is in a metastable state, reaction (1) is called the Penning effect and can be in-