

neutron groups and taking into account the behavior of the detector efficiency with energy, it is possible to say that the cross section of production of a neutron of the second group at 0° , relative to the deuteron beam in the case $T + d(E_d = 14.4 \text{ mev})$ is approximately 300 millibarn/sterad, and, in the case $D + d(E_d = 13.0 \text{ mev})$, 100 millibarn/sterad.

The authors express their gratitude to colleagues in the Cyclotron Laboratory, headed by L. M. Nemenov, for providing the possibility of carrying out this work.

* The results of this work were communicated in the discussion at the Geneva conference in August, 1955.

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Translated by G. Brown
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Gamma and Photoluminescence Yields in Organic Crystals

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(Submitted to JETP editor July 19, 1955)

J. Exper. Theoret. Phys. USSR **30**, 187-188

(January, 1956)

THE spectrum of luminescence due to gamma ray excitation coincides with the spectrum of photoluminescence¹. This means that the last step in the process of the excitation of gamma luminescence is the transition from the same excited state that is involved in photoexcitation. Therefore, the energy yield for gamma luminescence can be represented as $B_\gamma = \rho B_\phi^q$, where B_ϕ^q is the absolute quantum yield of photoluminescence, depending on the correlation between the transitions with and without radiation; ρ can be called the effectiveness of the excitation. The magnitude of ρ shows what fraction of the energy absorbed in the substance is used for the excitation of the molecules which are effective in luminescence.

The aim of the present paper was to see if the magnitude of ρ is the same or differs appreciably for a number of substances. For this purpose the relative yields during gamma and photoexcitations were measured. Aromatic carbohydrates in the shape of monocrystals (dimensions $1.5 \times 1.2 \times 0.7 \text{ cm}^3$) were investigated, and for

comparison purposes the alkali-halide crystals NaI and KI, activated by Tl. Co^{60} was used as the source of gamma rays.

During the gamma excitation the amounts of energy absorbed in the crystals were determined from the relative absorption coefficients of gamma rays. As is known, during the passage of gamma rays through the substance the electrons are freed, and these electrons cause luminescence. The absorption of gamma rays with an energy of the order of 1 mev in organic substances takes place at the expense of the formation of Compton electrons; in NaI and KI crystals the probability for the Compton effect is 95% and the remaining 5% are due to the photoeffect. The probability of the Compton effect is proportional to the number of electrons; the number of electrons in P grams of the substance is $(PZ/M)N$, where Z is the number of electrons in a molecule, M - molecular weight, N - Avogadro's number.

Relative yields for gamma excitation were measured by two methods: a) by the observation of the average intensity of luminescence, b) by the observation of individual scintillations. For the measurement of the average intensity of luminescence, the crystal was placed in a photometric sphere which was covered on the inside with MgO. The light of the luminescence, excited in the crystal by gamma rays, went through an opening in the sphere and was incident on the window of the photomultiplier FEU-19. The values obtained for the photocurrent were divided by $(PZ/M)N$. A scintillation counter with an integral discriminator was used for the determination of the relative magnitude of the scintillations. For a comparison of the magnitude of the impulses it is necessary to reduce the distribution curves to such a scale that the total number of impulses contributing be the same; for this reason the ordinates of each curve were divided by $(PZ/M)N$. For the comparison of the relative magnitudes of the impulses the method of constant counting rates was used, i.e., the magnitudes of the displacements were compared, when the counting rate was the same for different crystals.

Measurements of the relative yields of photoluminescence were made during excitation by the 254 $\mu\mu$ line. This line was separated from the light emitted by the PRK-2 lamp by means of a monochromatic quartz and was focussed on the surface of the crystal which was placed in the photometric sphere. The sphere had two windows: one for the entrance of the excitation light, and one for the photomultiplier. The absorption of 254 $\mu\mu$ line in organic crystals is known to be complete,

Substance	$\bar{\lambda}$, m μ	k	B_{ϕ}^q , %	B_{γ} , %		ρ , %	
				1	2	1	2
Tolane	380	1.14	50	0.60	0.59	1.2	1.2
Stilbene	394	1.10	50	0.61	0.61	1.2	1.2
Naphthalene	350	1.23	17	0.21	0.23	1.2	1.4
Terphenyl	395	1.12	30	0.30	0.34	1.0	1.1
Dibenzyl	373	1.25	44	0.39	0.40	0.9	0.9
KI - Tl**	417	1.02	76	1.7	0.71	2.2	0.9
NaI - Tl**	411	1.0	66	1.25	1.21	1.9	1.8
Naphthalene with anthracene . .	—	—	—	—	0.7 \pm 0.2	—	—

the fraction of reflected light, according to the measurements by Morgenshtern made on the same samples², is 10-16%. Alkali-halide crystals were excited with the 291 m μ line in the first absorption band of Tl.

As a result of the measurement for gamma excitation as well as for photoexcitation, magnitudes proportional to $\int E_{\lambda} f_{\lambda} d\lambda$ were obtained, where E_{λ} is the energy distribution in the luminescence spectrum, and f_{λ} is the spectral sensitivity of the photomultiplier. In order to convert to magnitudes, proportional to the real yields, i.e., $\int E_{\lambda} d\lambda$, we measured f_{λ} and E_{λ} for all substances. From these data the magnitudes of $\int E_{\lambda} d\lambda$ were determined in relative units. Previously we measured the absolute quantum yields of photoluminescence for naphthalene and stilbene³, and in reference 4 the absolute energy yield for gamma excitation of crystals of naphthalene with anthracene. This allowed us to give all magnitudes of yields in the absolute scale*.

In the above table $\bar{\lambda}$ — is the average wave length of the luminescence spectrum, K — relative sensitivity of the photomultiplier for the luminescence spectra, which is equal to $\int E_{\lambda} f_{\lambda} d\lambda / \int E_{\lambda} d\lambda$; B_{ϕ}^q , B_{γ} and ρ have the meaning given above. The magnitudes in columns 1 are from the measurements of the average intensity, those in columns 2 are from the scintillation measurements. For organic crystals ρ is the same with the precision $\pm 15\%$; this precision is within the limits of accuracy of the experimental measurements. The variation of ρ for the organic alkali-halide crystals cannot be explained by the fact that the latter have a greater probability for the photoeffect, and thus points out the different processes of excitation in these two types of crystals. The difference in the magnitudes of the yield in KI - Tl, as determined by the average intensity and by the scintillations methods, is explained by the phosphorescence of KI - Tl, which is not taken into account in the method of

scintillations.

We express our gratitude to L. M. Beliaev for submitting the crystals.

* The data obtained should be considered as the characteristics of the given samples, and not the substances, since it is possible that the samples contained small impurities which would influence the yield of luminescence.

** Crystals NaI and KI contained Tl in the concentration of the order of 10^{-3} gm/gm; this corresponds to a region where the intensity of gamma luminescence depends weakly on the concentration⁵.

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Translated by M. Polonsky
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Influence of Intermolecular Forces in Solutions on the Intensity of Raman Lines

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(Submitted to JETP editor December 6, 1954)

J. Exper. Theoret. Phys. USSR 30, 189-190

(January, 1956)

EARLIER^{1,2} one of us observed anomalies in the thermal behavior of the intensities of the primary Raman series lines and explained these on the basis of the hypothesis of reciprocal deformation of