shown in Fig. 3. The luminous intensity in Figs. 2 and 3 and in the table is given in the same units. The short term [initial response] luminescence at 0 °C with the scintillator excited by ∝-particles or γ-rays amounts to about 2500 such units.

The experimental results not only prove the existence of persistent luminescence (afterglow) and thermoluminescence for organic plastic scintillators excited at low temperatures by ionizing radiation, but also demonstrate that there are quantitative differences in the nature of the luminosity effects with ∝-as against γ-excitation. With ∝-excitation the decrease in short-term luminescence begins at a lower temperature than with γ-excitation and the afterglow intensity is appreciably lower. Thermoluminescence with ∝-particle excitation is relatively weak, particularly if we take into account the fact that the energy absorbed by the plastic scintillator with ∝-excitation exceeded the energy input with γ-ray excitation by a factor of 10. A possible reason for the difference is appreciable local heating of the scintillator in the ∝-particle track.

In any case it is obvious that temperature effects must be duly taken into account in any attempt to explain the dependence of the scintillation output on the speed and charge of the exciting particles.

Translated by E. Rosen
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F-Centers in Silver Halide Crystals

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IN a recently published article Grenishin[1] asserts that the absorption bands of AgBr at $\lambda = 420\text{-}430$ mμ (studied first by the writer in collaboration with Putseiko[2] and subsequently by the writer[3,4] alone) are in no way connected with the presence, in the silver halide crystals, of F-centers, similar to the F-centers found in the halides of alkali metals. By way of proof Grenishin cites the presumed temperature independence of the half-width of the absorption bands and the absence of vacant lattice sites in silver halides.

The first statement is erroneous: Grenishin used data taken from our report on experiments in which the temperature was varied only in a narrow interval. Experiments carried out by the writer in collaboration with Shimanskii[5] showed that when the temperature of AgBr is changed from 90-100 °C to 350 °C the half-width increases, on the average, by a factor of 1.6-1.7 and in the case of heating to 408 °C, by a factor of 1.8-1.9. Heating of an AgCl crystal also leads to a 1.6-fold increase in the half-width of the absorption band. This is clearly illustrated by the data listed in the table below*.

It will be seen from the table that the variation of the half-width of the F-center absorption band with the temperature is of the same order as for the halides of alkali metals[6].

As for the second statement, it is true that no vacant halide ion sites (such as occur in alkali metal halides) are formed by the mechanism of Schottky in silver halides. However, this is no proof that F-centers cannot form by the mechanism of de Boer. The writer has suggested a possible mechanism of the formation of F-centers in silver halides. By virtue of the close packing of the crystal lattice and the partially homeopolar nature of the bonds there is a certain probability of the transfer of an electron from the halide ion to the one of the six neighboring silver ions, with the subsequent escape of a halide atom and the formation of an F-center in its place. The activation energy for the process is approximately 0.15 eV[5]. Due to the low value of this activation energy the F-center absorption band overlaps the intrinsic absorption band. With different ratios of the intensity of the two bands,

Half-width in eV

Temperature in °C	Crystals						
	AgBr						AgCl
	№ 1	№ 2	№ 3	№ 4	№ 5	№ 6	
90	0.22	0.42	0.24	0.46	0.23	0.34	0.22
350	—	0.60	0.44	0.57	0.35	0.57	0.35
408	0.47	0.76	—	0.87	0.42	—	—

the apparent maximum of the F-center absorption band may be displaced to some extent. Some investigators fail to take this circumstance into account and hence place an erroneous interpretation on the relative shift of the F-center absorption band for different silver halide crystals, as contrasted with the invariable position of the F-center peak for alkali metal halides, although it is known that for the latter the F-center band is well separated from the intrinsic absorption band.

It is shown in Grenishin's article that the F-center absorption increases with the ripening time of the emulsion. This was also shown in my communication[3].

Translated by E. Rosen
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* P. S. Shimanskii has kindly supplied the listed data.

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On the Resonance-Fluorescence of Atoms

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ONE of the present authors[1] recently investigated the statistical relation of the radiation absorbed and the radiation emitted by a system, consisting of atoms with two energy levels. It was shown that the radiation output of such a system may vary, depending on the density of the exciting radiation. This deduction applies to the total output, i.e., to the ratio of the total energy emitted to the total energy absorbed.

In the present communication we propose to apply the suggested method to calculating the luminescence output of such a system, for example, to the resonance fluorescence of atoms.

According to the definition given by Vavilov[2], luminescence is understood to mean the excess of the radiation over temperature radiation, having a finite duration which exceeds the period of light oscillations. This definition corresponds to the experimental conditions under which luminescence output is normally measured. It will be recalled that any radiation detector does not register the background of "black body" radiation, corresponding to its temperature (since it is in equilibrium with this background), and reacts only to the excess radiation over and above this background. It follows that in determining the exciting light-energy absorbed by the body as well as the light energy radiated by the luminescent body, we measure only the excess above the heat radiation.

Taking this factor into account we obtain the following expression for the output of photoluminescence in place of Eq. (15) of reference 1:

$$q = \frac{(A + Bu_0)\, n_2 - Bu_0 n_1}{Bs\,(n_1 - n_2)}\,. \tag{1}$$

The symbols are as given by Stepanov[1] : s is the energy density of the exciting light, An_2 is the number of spontaneous transitions, accompanied by radiation, from the upper level per unit time, Bu_0n_2 is the number of transitions from this level, forced by heat radiation, the density of which, for the frequency $\nu = (E_2 - E_1)/h$, equals u_0. The resultant forced radiation is characterized by a certain duration, since it continues after the cessation of excitation until the number of molecules in the higher excited state drops to the number consistent with thermodynamic equilibrium. Hence the $(A + Bu_0)n_2$ term represents the total number of quanta released per unit time. A certain number of these quanta is not recorded by the detector since it serves to compensate the number of quanta of black-body radiation absorbed by the system. This number per unit time is Bu_0n_2 . Hence in determining the luminescence energy this term must be substracted from the numerator.

In the denominator of Eq. (1) we also have only the excess of radiation (absorbed in this case) over the black-body radiation background. As in reference 1, the forced emission under the influence of the exciting radiation is regarded here as equivalent to a reduction of the absorption.

In reference 1 it was shown that with constant excitation

$$\frac{n_1}{n_2} = \frac{A + B\,(u_0 + s) + d_0}{B\,(u_0 + s) + d_0 \exp\{h\nu/kT\}}\,. \tag{2}$$

Substituting (2) in (1), we find that the quantum output of fluorescence is