

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 communication³.

Translated by E. Rosen

44

* P. S. Shimanskii has kindly supplied the listed data.

¹ S. G. Grenishin, *J. Exper. Theoret. Phys. USSR* **26**, 736 (1954)

² E. K. Putseiko and P. V. Meikliar, *J. Exper. Theoret. Phys. USSR* **21**, 341 (1951)

³ P. V. Meikliar, *Doklady Akad. Nauk SSSR* **77**, 391 (1951)

⁴ P. V. Meikliar, *Proceedings of the Meeting dedicated to the memory of Academician S. I. Vavilov*, Moscow, 1953, p. 214.

⁵ P. V. Meikliar and R. S. Shimanskii, *J. Exper. Theoret. Phys. USSR* **27**, 156 (1954)

⁶ N. Mott and R. Gurney, *Electronic Processes in Ionic Crystals*, p. 138

On the Resonance-Fluorescence of Atoms

M. N. ALENTSEV, V. V. ANTONOV-ROMANOVSKII,
B. I. STEPANOV AND M. V. FOK

*P. N. Lebedev Physical Institute,
Academy of Sciences USSR*

*Physical Institute of the Academy of Sciences,
Byelorussian SSR*

(Submitted to JETP editor November 25, 1954)

J. Exper. Theoret. Phys. USSR **28**,
253-254 (February, 1955)

ONE of the present authors¹ 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 Vavilov², 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:

$$q = \frac{(A + Bu_0)n_2 - Bu_0n_1}{Bs(n_1 - n_2)} \quad (1)$$

The symbols are as given by Stepanov¹: 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 subtracted 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

$$\frac{n_1}{n_2} = \frac{A + B(u_0 + s) + d_0}{B(u_0 + s) + d_0 \exp\{hv/kT\}} \quad (2)$$

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

$$q = \frac{1}{1 + (d_0/A) [1 - \exp \{-h\nu/kT\}]} \quad (3)$$

The principal deduction to be drawn from the above is that q is independent of the density s of the exciting light, in which respect it differs from the quantum output of the total radiation. The latter is a monotonic function of s , tending to unity as $s \rightarrow 0$ and to the magnitude of q when $s \rightarrow \infty$ ¹.

For $d_0=0$, i.e. in the absence of radiationless transitions, we obtain the trivial result $q=1$. The output q also equals unity when the temperature is so high (flame temperatures) or the transition frequency ν so low (radio frequency region) that $\exp \{-h\nu/kT\}$ virtually equals unity. In physical terms, this means that under such conditions the presence of external radiation does not disturb the energy distribution between the levels, and consequently the number of quenchings equals the number of excitations, i.e., no heat is lost (radiated).

Under the conditions commonly obtained in luminescence experiments the value of $\exp \{-h\nu/kT\}$ is approximately zero and, therefore, according to (3),

$$q = A/(A + d_0). \quad (4)$$

Translated by M. Rosen
45

¹ B. I. Stepanov, Doklady Akad. Nauk SSSR 99, 971 (1954)

² S. I. Vavilov, Introduction to the Russian translation of "Fluorescence and Phosphorescence" by P. Pringsheim.

Self-Neutralizing Light Meter with Adjustable Red Boundary

M. S. KHAIKIN AND E. I. ABAULINA

*Institute for Physical Problems,
Academy of Sciences, USSR*

(Submitted to JETP editor June 29, 1954)

J. Exper. Theoret. Phys. USSR 28, 254-256
(February, 1955)

THE photoelectric meter is the most sensitive instrument for measuring the luminous flux¹; therefore, work on its perfection or the extension of its application presents practical interest. This article is devoted to experiments on the design of a photometer with controllable spectral characteristics. Such an instrument could combine the functions of a light receiver and spectrometer. The first experiment in this direction was

carried out by Kudriavtseva².

In order to control the red boundary of spectral sensitivity of the photometer, an additional electrode, a screen, was installed near the photocathode of the meter. The retarding field, created between the screen and the photocathode permitted the selection of the photoelectrons, passing through the screen into a sensitive zone of the meter, according to their speeds. In order that such a separation of photoelectrons be effective, it is necessary that the electrons not lose the speeds obtained under the photoelectric effect on the path from the photocathode to the screen (in absence of the restraining field), i.e., that the distance between the screen and photocathode shall be of the order of the free path length of the electrons in the gas in the meter. For this purpose the distance from the screen to photocathode should be made very small, or about 50 μ , and the argon gas should be used to fill the meter; in argon the mean free path is a maximum for electrons with velocity 0.3 - 1.5 V³. As the neutralizing component of the mixture methylal was used in 10% strength; the pressure of the mixture in the meter was 80 mm of mercury.

The meter had a cylindrical shape. A thin wall tube, 15 mm in diameter, of non-corrosive steel served as the cathode. The slits (12 \times 8 mm) were cut on the opposite sides of the tube. One slit was used for illumination, and another was covered by a screen, behind which the cylindrical aluminum photocathode was attached to the insulation support. The aluminum was of a type having a red boundary for the photoelectric effect of about 3500 Å (3.6 eV). The screen was made of 20 micron tungsten foil by means of anodic etching under a thin rolled copper screen, pressed to the foil surface. In such a manner a copy of the copper screen was impressed on the tungsten foil, the cells of which were 0.33 \times 0.25 mm and the transparency about 60%.

The tungsten metal was selected for preparation of the screen on account of its high energy yield. It served the purpose of lowering the uncontrollable photoeffect from the screen surface under illumination by the light under investigation. A steel cathode tube was subjected to chlorinization for the same purpose.

The complete meter represented a separate apparatus suitable for long work¹. The anode and cathode of the meter were connected in the usual manner in a standard measuring system. The voltage given between the photocathode and screen (connected with the cathode of the meter) was supplied from a potentiometer, fed by dry cells.