The angular distribution of protons obtained by us differs very much from the Coulomb distribution and is not the same for various nuclei. Qualitative similarity in scattering by neighboring nuclei is observed. Thus, for Be and C a large scattering in the region of the angles 150-160° is obvious; however, the numerical value of the ratio for carbon is almost 4 times bigger than for beryllium. Apparently this is connected with the formation of the intermediate nucleus of N^{13} , which in this region of energies has an excitation level which gives rise to the resonant scattering of protons. Note that for an energy of 10 mev for carbon and for beryllium for 5.4 mev, a maximum at 50° [6] is observed. The curve for fluorine has a maximum for 140°. There is no data for scattering of protons from fluorine. but its neighbor — oxygen, has a big scattering maximum in the region of 120° for 9.6 mev.[5]

Scattering by magnesium and aluminum is similar, with a somewhat greater absolute value of the ratio for Mg. The angular distribution for Ni, Cu and Zn, within the experimental errors is alike in the magnitude of their ratios and in the position of maxima and minima. Similar curves for Cu were obtained by Goldman [7] for a proton energy of 6.5 mev; and by Schneider, Martin et al[8] for energies of 6, 6.5 and 7 mev. For Mn, qualitatively the curve for angular dependence is analogous to the preceding elements, but a displacement of the position of the minimum and second maximum in the direction of greater angles is observed, and the maximum is somewhat bigger. An unexpectedly large magnitude for the ratio for Ca was obtained, especially for big angles. It is possible that this was obtained as a result of two types of operation, which we were forced to do in these experiments; however, the fact is not excluded that this large effect is caused by a characteristic of the nucleus of Ca^{40}. The interesting fact is that, in spite of the small value of the ratio measured by us for heavier nuclei, the interference character of elastic scattering from these nuclei appears more clearly than for light nuclei.

Our attempts to explain the obtained results by the optical model have been as yet unsuccessful. It is possible, that the optical model in its present state is only a rough approximation for consideration of proton scattering, for which one must take into consideration a complex dependency on the potential of the nucleus, whose form can change. Obviously, further study of proton scattering at various energies and from a number of nuclei is necessary. Especially important is further study on free protons, which we are undertaking.

In conclusion the authors consider it their duty to express great thanks to Prof. K. D. Sinelnikov for discussion and constant interest in our work, and also to P. M. Seidlitz for his great attention which helped in the completion of work.

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104.

Photoconductivity and Luminescence of Polycrystalline CdS (Cu)

N. A. Tolstoi, B. T. Kolomets, O. I. Golikiva and M. Ia. Tsenter

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POLYCRYSTALLINE cadmium sulfide[1] with just a trace of a foreign metal represents a very convenient specimen for investigating the laws of photoconduction and luminescence. The results are summarized here of a preliminary investigation of the stationary (steady-state) and relaxation laws of a series of CdS specimens with just a trace of copper, and also copper and iron. The CdS (Cu) series consisted of 9 specimens (several of each) with various concentrations C (gms/gm) (see table)

Specimen number 10, CdS (Cu, Fe) had concentrations of Cu and Fe of 10^{-3} and 10^{-5} grams/gram, respectively.

1. Stationary (steady-state) photoconduction. The dependence of stationary photoconductivity $\Delta\sigma_0$ on the level of intensity of light E in specimens with small concentration (SC) of copper appears typical of photoconduction of the "hyper-

No.	C	No.	C
1	0	6	10^{-4}
2	10^{-6}	7	2.5×10^{-4}
3	10^{-5}	8	5×10^{-4}
4	2.5×10^{-5}	9	10^{-3}
5	5×10^{-5}		

bolic" type^2 : $\Delta\sigma_0$ grows slowly with E, showing some tendency to saturate "sublinear dependence" On the other hand, for high concentration (HC) specimens, $\Delta\sigma_0$ increases rapidly with E ("superlinear dependence"). In certain cases (No. 9 and No. 10) one observes a quadratic dependence ($\Delta\sigma_0 \sim E^2$). Specimens with intermediate concentrations show a dependence of $\Delta\sigma_0$ (E) that is nearly linear. All of these have a region of excitation that is in the ultraviolet part of the spectrum (mercury lines 365, 546 and 578 mμ; incandescent lamp with a green filter). Fig. 1 illustrates the dependence of σ (E).

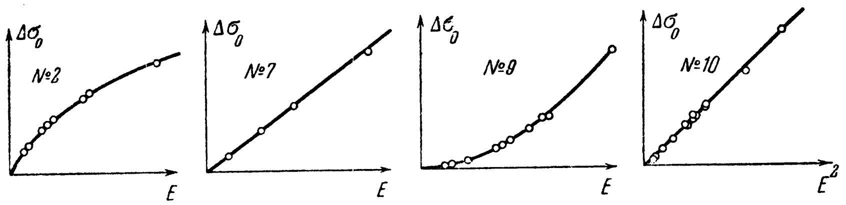

FIG. 1

The transition from sublinear to superlinear dependence takes place at a concentration of the order of several units of 10^{-4} grams/gram. As regards the dependence of σ_0 (E) for specimens with other concentrations C and different kinds of nonlinearity; comparison with photosensitivity is strictly speaking, meaningless. Nevertheless, it should be noted that through this range the values of E for specimens in the transition from LC to · HC first increase the sensitivity and then abruptly reduce it. Dark conduction associated with the transition from LC to HC drops sharply.

2. Stationary luminescence. All specimens investigated were intensely illuminated in the red and infrared regions of the spectrum. Excitation was by the mercury 365 and 546 m μ lines. For samples of LC the brightness of stationary luminescence I_0 is proportional to E. For the HC specimen the dependence of I_0 (E) is superlinear. In some cases (No. 9 and No. 10) there is a quadratic relationship: $I_0 \sim E^2$. The transition from linear to sublinear dependence for luminescence is associated with somewhat smaller concentrations of activator than the transition from linear to sublinear dependence for photoconduction.

Figure 2 illustrates examples of the relationship $I_0 \sim E^2$.

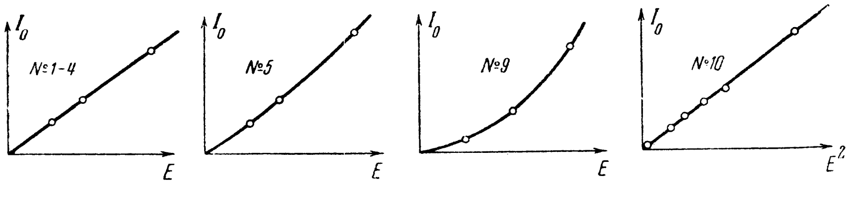

FIG. 2

3. **Relaxation of photoconduction.** Since the relaxation curves are not exponential, we show only the variations in their integral and differential characteristics. We first[3,4] introduced the areas above the growth curves (L_G)and the areas under the falling curves (L_F) ; we then[5] introduced the rate of growth of photoconduction from the instant the light was turned on (or the maximum velocity) $\Delta\sigma'_{OG}$ and the rate of decay of photoconduction from the instant the light is turned off, $\Delta\sigma'_{OF}$. Generally speaking, the above quantities are related to $\Delta\sigma'_0$, but we are interested only in the relations L_G/L_F and $\Delta\sigma_{OG}/\Delta\sigma'_{OF}$, from which $\Delta\sigma$ drops out.

For the LC samples $L_G/L_F < 1$, $\Delta\sigma'_{OG}/\Delta\sigma'_{OF} > 1$. Roughly speaking, the curves of growth increase rapidly. These results are typical for kinetic hyperbolic photoresistance, in general. For the HC specimens and No. 10 $L_G/L_F >> 1$ x $\Delta\sigma'_{OG}/\Delta\sigma'_{OF} << 1$: the growth curve increasing more slowly than the falling of the decay curve (Fig. 3). Further, the initial form of the growth curves\was a parabolic character: $\Delta\sigma \sim t^2$ for small t, i.e., the growth curves have an inflection.

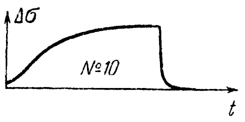

FIG. 3

4. **Relaxation of luminescence.** There is evidence of analogous characteristics for the curves of emission (flaring) and decay of luminescence, and one can ascertain the following: for the LC specimens $L_E/L_D \leq 1$, $I'_{OE}/I'_{OD} \geq 1$ (this is typical for ordinary kinetic hyperbolic phosphors in the absence of quenching). For the HC specimens and No. 10 $L_E/L_D >> 1$, $I_{OE}/I_{OD} << 1$, i.e., the curve of growth curving more slowly than the decay curve (Fig. 4). The growth curve increases parabolically at first and then twists (inflects). However, the relaxation characteristics are typical of concentration – or temperature– extinction phosphors of the hyperbolic type [for example, ZnS (Cu) and reference (6)] .

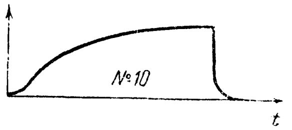

FIG. 4

5. **Discussion.** The alterations in the stationary and the relaxation law of photoconduction with increasing concentration can be seen to run parallel. Concentration quenches luminescence concomitantly with concentration quenching of photoconduction. Now, for CdS (Cu, Fe) the limit of quadratic dependence is particularly distinct, which is understandable if it is recalled that iron exhibits "classical" quenching with sulfides. The relationships $I_0 \sim E^2$, $I_E \sim t^2$ for small t, $L_E/L_D > 1$, are in agreement with the bimolecular theory of phosphorescence, in terms of lowest deterioration in the presence of pronounced quenching.[7] But it is possible to show that a value of $L_E/L_D > 3$ is not reconciliable with the bimolecular theory .[4] Experiments, however, yield values of L_E/L_D that go as far as 100. On the other hand, the dependence of $\Delta\sigma_0 \sim E^2$, $\Delta\sigma_{II} \sim t^2$ for small t and $L_H/L_C > 1$ sharply contradicts any recombination schemes, departing from the usual idea of the mechanism of excitation, but agreeing well with the theory based on the "two-stage" mechanism of excitation.[8,9]

Making a natural hypothesis suggested by this, namely, that the mechanisms of emission and photoconduction with CdS (Cu) and with CdS (Cu, Fe) exhibit a certain measure of unity, we are led to conclude that the relationships $I_0 \sim E^2$, $I_E \sim t^2$ likewise are not connected with the bimolecular degeneration mechanism of recombination, but with a two-stage mechanism of excitation (stimulation).

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105