The presence of the Gaussian functions in the integrand insures a rapid enough convergence so that the integral equation can be replaced by a finite set of linear algebraic equations. It was found in this calculation that for $r \lesssim 13a$ the contributions to the integrals were practically zero.

Since both doublet (d) scattering, $S=\frac{1}{2}$ and quartet (q), $S=\frac{3}{2}$ scattering are present, we had to solve two sets of equations for the two values of the total spin. For thermal neutrons ($k=0$) and for the special choice of potential given by $g=0.2$, $g_1=g_2=0$,[1] we obtained

$$\phi_d(13a)=1.0546; \quad \phi_q(13a)=0.749$$

and

$$|f_d(\theta)|=|\phi_d(13a)-1|(13a)=1.59\times 10^{-13}\text{ cm},$$
$$|f_q(\theta)|=|\phi_q(13a)-1|(13a)=7.302\times 10^{-13}\text{ cm}.$$

From this the scattering cross section was found to be

$$\sigma_t=\frac{4\pi}{3}(2|f_q(\theta)|^2+|f(\theta)|^2)$$
$$=4.57\times 10^{-24}\text{ cm}^2.$$

The recent experiments of Carroll and Dunning (to be published) give the value 5.7×10^{-24} for this scattering cross section. If one takes molecular binding into account, this value has to be reduced by a factor which lies between 1.5 and 2.[3] At best, then, the theoretical value is about 20 percent too large. This discrepancy may be accounted for by polarization effects.

We should like to express our thanks to Mr. Jerome Rothstein of Columbia University for aiding in the numerical work.

Lloyd Motz

Columbia University,
New York, New York,

Julian Schwinger**

The University of California,
Berkeley, California,
December 18, 1939.

* Publication assisted by the Ernest Kempton Adams Fund for Physical Research of Columbia University.
** National Research Fellow.
[1] G. Breit and E. Feenberg, Phys. Rev. **50**, 850 (1936).
[2] N. E. Mott and H. S. W. Massey, *The Theory of Atomic Collisions* (Oxford Univ. Press, New York, 1933), Chap. IV.
[3] L. I. Schiff, Phys. Rev. **52**, 149 (1937).

Absorption Spectrum of Single-Crystal ZnS Phosphors

A knowledge of the absorption spectrum of a phosphor is necessary if one is to understand the process by means of which radiation is emitted by the phosphor. In view of the experimental difficulties encountered in obtaining the absorption spectrum of a powder, it seems desirable to study the absorption spectrum of a ZnS phosphor in the form of a single crystal; especially so, since there seems to be some uncertainty as to the nature of the absorption process in activated ZnS.[1]

Several ZnS single crystals, approximately one millimeter square and a few tenths of a millimeter in thickness, were obtained through the kindness of Dr. R. P. Johnson and Mr. F. B. Quinlan of the General Electric Company. The crystals were made by firing in vacuum a precipitated ZnS with about 0.004 percent Cu. Each of three crystals was mounted behind a small hole in black paper and then placed in front of the slit of a small Littrow quartz spectrograph. Light from a condensed iron spark was focused on the crystal by means of a quartz lens. The spectra were photographed on Eastman Spectroscopic Plates, Type IV–O. Three identical two-minute exposures were taken with the ZnS crystal in position. The crystal was then removed and six comparison spectra of 1, 2, 4, 8, 16, and 32 seconds exposure were placed on the plate so as to bracket each of the original spectra. The intensities of the lines in the original spectra were determined visually by matching densities with one of the comparison spectra, whose exposure time was then taken as a measure of the intensity in question.

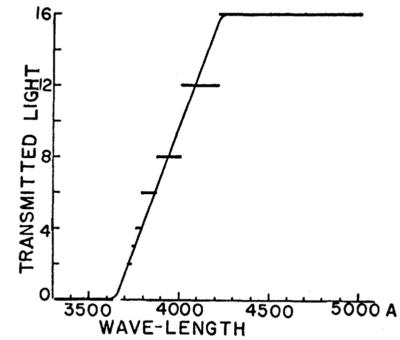

Fig. 1. Relative intensity of the light transmitted by a ZnS·Cu single-crystal phosphor *vs.* the wave-length, in angstrom units.

The absorption curves obtained in this way for three of the ZnS single-crystal phosphors were quite similar; a typical curve, shown in Fig. 1, indicates that for this phosphor, absorption is partial for wave-lengths less than 4250A and is complete for wave-lengths less than 3650A. This absorption curve is in good agreement with the curve obtained by Kitchener[1] from a ZnS·Cu powder, using the diffuse reflection method. Gisolf has reported[2] a secondary absorption peak on the long wave-length side of the absorption edge of ZnS phosphors; nothing of this nature is clearly shown by the accompanying curve, although there seems to be a slight asymmetry in the absorption edge which may be due to an unresolved secondary absorption peak. Nor was any evidence found of absorption bands in the region 4200–5000A, such as have been reported by Kroger[3] for ZnS·MnS mixed phosphors. Any such partial absorption which would reduce the intensity of the transmitted light by as much as one-fourth should have been detected.

Charles J. Brasefield

U. S. Coast Guard Academy,
New London, Connecticut,
December 22, 1939.

[1] See, for example, page 97 of "Luminescence, A General Discussion held by the Faraday Society, September 1938" (reprinted from the Transactions of the Faraday Society, Vol. 35); and references mentioned there.
[2] J. H. Gisolf, Physica **6**, 88 (1939).
[3] F. A. Kroger, Physica **6**, 374 (1939).