

LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the

twentieth of the preceding month; for the second issue, the fifth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

A Note on the Band Spectrum of Silicon Fluoride

A few years ago Johnson and Jenkins¹ examined the spectrum of a discharge in silicon fluoride gas and found evidence of several band systems. One of these they examined in some detail and attempted a rotational analysis of what is apparently the (0,0) band at $\lambda 4368$. They found a very large moment of inertia for the emitter which led them to very improbable conclusions as to its structure and nature.

We recently had occasion to examine the data of Johnson and Jenkins and noticed some peculiarities which suggested a possible error in their analysis. Among other things there is an indication of an alternation of intensity in the lines in one region of the $\lambda 4368$ band and also considerable irregularity in the spacing which suggests that the lines do not all belong to the same band.

We have consequently reexamined under very high dispersion the violet portion of the spectrum obtained in the silicon fluoride discharge and have found some interesting features not previously noted. There are apparently two systems in the region with considerable overlapping of bands from the two. The superposition of two bands at $\lambda 4368$ is so perfect that it does indeed give the impression at first that all the lines belong to one band. On closer examination one observes two band heads, very close together, which the previous workers apparently did not resolve, and quite strikingly the alternation of intensity and irregularity of spacing which were merely indicated by their data. There is very little doubt that only every other line belongs to one band and the remainder to a second, as there are several bands in the region where overlapping does not occur and which show twice the line spacing of the $\lambda 4368$ structure. Wherever two bands do practically coincide violent perturbations are observed in some portion of them.

Since Johnson and Jenkins calculated the rotational constants on the assumption that all the lines in the $\lambda 4368$ structure belonged to one band it is evident that they obtained moments of inertia about twice too large. If one takes half these values and calculates the internuclear distances on the assumption that the emitter is the SiF molecule, one obtains very reasonable results.

A further study of the spectrum is in progress and details will appear shortly.

RICHARD M. BADGER
CHARLES M. BLAIR, JR.

Gates Chemical Laboratory,
California Institute of Technology,
April 29, 1935.

¹ R. C. Johnson and H. G. Jenkins, Proc. Roy. Soc. A116, 327 (1927).

Scattering of Neutrons

In view of the recent measurements of Dunning, Pegram, Fink and Mitchell¹ on the absorption of fast and slow neutrons by various metals and of the rather large absorption cross sections shown by some metals for slow neutrons, we have made a preliminary investigation of the scattering of neutrons by several substances.

A bulb *S* containing radon (240 millicuries to 80 millicuries) and beryllium was placed in a cylinder of paraffin as shown in Fig. 1. After passing through 6 cm of paraffin, the neutrons from the source struck a silver foil, 6×10 cm, and then were scattered from blocks of metal the same size as the silver foil, placed above it. The scattering was measured by observing the increase in the radioactivity of the silver foil caused by the presence of various thicknesses of scatterer.

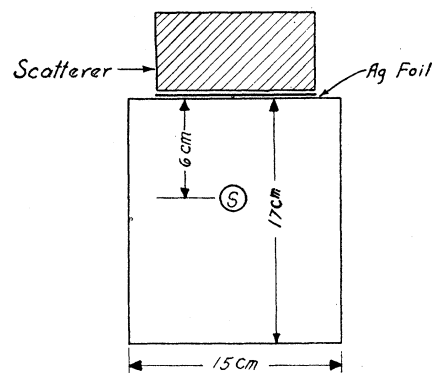


FIG. 1. Arrangement of scattering metal, silver foil and paraffin block containing the neutron source *S*.

The radioactivity induced in the silver by neutrons was first measured with no scatterer present. This was accomplished by placing the foil in the position as shown and irradiating it for 6 minutes. The sample was then removed and wrapped around a Geiger-Müller tube counter having thin aluminum walls. Counting was begun one minute after removing the sample and was continued until the end of the fifth minute, readings being taken every half minute. The activity of the foil was then given by the total count in this interval minus the natural count of the Geiger-Müller tube. A similar procedure was carried out when the scatterer was placed above the foil as shown in the diagram. The percentage increase in the activity of the silver sample (i.e., activity of the silver with scatterer present minus activity of silver alone, divided by the activity of the silver alone) was plotted as a function of the thickness of the scatterer. On the average about 1000

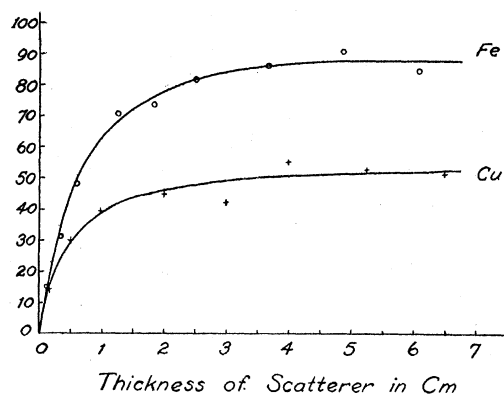


FIG. 2. Activity of Ag + scattering minus activity of Ag alone (in percentage) plotted against thickness of scatterer.

particles were counted in the four minutes when silver alone was present.

The results for iron and copper are shown plotted in Fig. 2. It will be seen that a thickness of about 3.5 cm of either is sufficient to give maximum scattering, which was about 52 percent for copper and 88 percent for iron. It should be noted that the number of atoms per square centimeter is the same in either case, since the atomic densities of iron and copper are about equal. The results are, of course, corrected for the decay of radon.

An attempt was made to get an approximate measurement of the relative number of slow and fast neutrons scattered back by copper. A sheet of cadmium 1 mm thick shielded the neutron source from the silver. With this arrangement about 25 percent as many counts were obtained with Cd as without, indicating that this fraction is due to fast neutrons. A thickness of 4.3 cm of copper placed on top of the silver caused an increase of about 50 per cent in the count.

In another series of experiments the silver foil was not shielded by cadmium from the source, but a sheet of cadmium 1 mm thick, and the same size as the sample, was placed on top of the foil. With this arrangement no change in the activity of the sample was noted. With 4.3 cm of copper placed above the silver and cadmium there was only an 11 percent increase instead of the 52 percent increase obtained without cadmium. This experiment, taken in conjunction with the one just described, indicates that the scattering of fast neutrons by copper is comparable to that of the slow ones.

We should like to thank Dr. Leo Szilard for many suggestions and much helpful discussion. We are indebted to Dr. C. B. Braestrup of the Physical Laboratory of the Department of Hospitals of the City of New York for many favors and also to the American Association for the Advancement of Science for a grant to one of us (A. C. G. M.) with the help of which apparatus has been purchased.

ALLAN C. G. MITCHELL
EDGAR J. MURPHY

Department of Physics,
New York University, University Heights,
May 4, 1935.

¹ J. R. Dunning, G. B. Pegram, G. A. Fink and D. P. Mitchell, Phys. Rev. 47, 416 (1935).

Precision X-Ray Wavelength Measurements

Precision measurements of the diffraction angles (or wavelengths) of x-ray lines are being made with the double crystal spectrometer with an observational error of 0.0002 to 0.001 percent.¹ The correction due to the divergence of the x-ray beam in the vertical plane which is to be applied to these measured angles is of the order of 0.002 percent.

The most recent and generally used correction formula is²

$$\delta\theta = [(a^2 + b^2)/24L^2] \tan \theta, \quad (1)$$

where a and b are the effective slit heights, L the distance between the slits and θ the Bragg angle. In view of the demands for increasing precision in wavelength determinations it should be pointed out that the numerator of Eq. (1) is in error and that the correct expression is

$$\delta\theta = [(a+b)^2/24L^2] \tan \theta \quad (2)$$

or, in case $\theta_A \neq \theta_B$, as in different orders or reflection or with dissimilar crystals,

$$\delta\theta = [(a+b)^2/48L^2] \lambda D, \quad (3)$$

where D , the dispersion, is given by

$$D = (1/\lambda)(\tan \theta_A \pm \tan \theta_B). \quad (4)$$

For slits of equal heights Eq. (2) differs from Eq. (1) by a factor of two. This angular shift due to the vertical divergence is toward larger values of θ and consequently $\delta\theta$ must be subtracted from the observed angles. Expressions (2) and (3) are derived from a simplification of Schwarzschild's treatment³ assuming the instrument is in proper adjustment.

If the diffraction patterns of the crystals are asymmetrical, as predicted by the Darwin-Ewald-Prins theory,⁴ a correction for this asymmetry should also be applied to the angle observed in any antiparallel position of the double spectrometer. The center of area of the asymmetrical pattern is shifted to a smaller value of θ and the correction would be added to the observed angle. As mentioned by Compton and Allison,⁵ this correction in the (1, +1) position, based on the theoretical diffraction patterns of calcite crystals, at the wavelength 1.54Å (Cu $K\alpha_1$) is of the order of magnitude of the correction for the vertical divergence of the beam and the two corrections approximately offset each other. However, the degree of asymmetry of the theoretical patterns varies markedly with wavelength. At the wavelength of, and less than, 0.71Å (Mo $K\alpha_1$) (which wavelength has been measured most accurately) the theoretical diffraction pattern of calcite is practically symmetrical. The center of area shift due to asymmetry increases with wavelength to 3.06Å, the K absorption limit of calcium. At wavelengths greater than 3.06Å the theoretical patterns are again more nearly symmetrical until the region of 5 to 6Å is reached where the asymmetry is about the same as, or slightly greater than, at 1.54Å.

No positive experimental information has been reported as to the supposed asymmetries of the crystal patterns but indications that such asymmetries do exist are apparent from recent measurements of the shapes of x-ray lines in various antiparallel positions of the spectrometer with various crystals.⁶