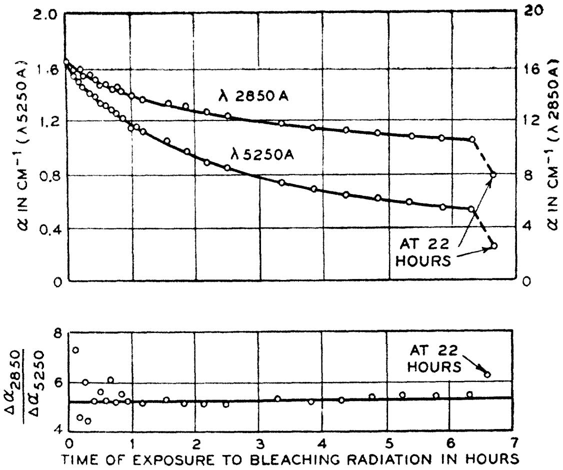

FIG. 3. The upper plot shows the effect of exposure to radiation from a tungsten lamp at wave-lengths greater than 6900A on the induced absorption at two wave-lengths. The lower plot gives the ratio of the *change* in absorption at these wave-lengths.

Attempts to make photo-conductivity measurements were confused and confounded by the presence of dark current which was variable during the course of measurement, and which undoubtedly contributed to a space-charge distortion of the electric field within the crystal. About all that can be stated with certainty is that after a crystal had been exposed to x-rays, visible light anywhere in the region of optical absorption gave rise to a change in the current through the crystal.

All measurements were made on samples obtained from the Norton Company, Niagara Falls, New York. Many of these were crystal clear, but some showed a slight yellow or greenish tinge. Others showed appreciable absorption in the ultraviolet before exposure to x-rays, as if they already contained centers giving rise to the 2850A and 2200A bands. The measurements we have here reported were made only on clear samples that exhibited a monotonically rising absorption in ultraviolet below 2500A. Spectrographic analysis revealed no impurities other than calcium ($\approx$0.1 percent).

The authors wish to express their appreciation to Miss Dorothy M. Dodd of these Laboratories for operating the spectrophotometer used in the experiments reported here.

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## Further Studies of Infra-Red Absorption by Homopolar Diatomic Molecules

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IN an earlier note[1] a report of studies of the infra-red absorption spectra of liquid nitrogen and liquid oxygen was given. These studies revealed the presence of a strong absorption band with center near 6.4$\mu$ in the spectrum of liquid oxygen and a strong band near 4.3$\mu$ in the spectrum of liquid nitrogen. These bands appear at positions where absorption would be expected if the fundamental vibrations of $O_2$ and $N_2$ were infra-red active. Several possible absorption mechanisms were suggested. After the presentation of, but prior to the publication of the earlier report, the note by Crawford *et al.*,[2] appeared; these authors gave an account of their work on $O_2$ and $N_2$ at high pressures and in the liquid state. They presented evidence that the bands at 4.3$\mu$ and 6.3$\mu$ are due to absorption by collision-induced dipoles.

Since the publication of our first note further studies of the spectra of liquid $N_2$ and $O_2$ have been made by another group at this university,[3] and we have studied the absorption of dry $O_2$ and $CO_2$-free $N_2$ in a vacuum prism-grating spectrograph. These gases were studied at a pressure of approximately one atmosphere. Although the early prism studies of Snow[4] indicated the presence of weak absorption bands in gaseous $O_2$ and $N_2$, we failed to observe any absorption that could be attributed to oxygen or nitrogen molecules. Careful studies with 7500 line/in. and 3600 line/in. gratings revealed no rotational lines for either gas when a path length of 5 meters of gas at a pressure of one atmosphere was employed. The only changes observed when $O_2$ and $N_2$ were introduced to the spectrograph was an enhancement of the residual $H_2O$ and $CO_2$ lines still observed when the spectrograph was evacuated as thoroughly as possible. On the basis of a rough determination of molecular absorption coefficients from measurements of absorption by liquids, a strong absorption was expected for a path length of 5 m in the gases. The absence of *any* observable absorption by the gases indicates that the close proximity of neighboring molecules is a necessary condition for the absorption process. Hence, this result supports rough theoretical calculations which indicate that processes involving magnetic-dipole and electric-quadrupole radiation do not contribute appreciably to the absorption observed for the liquids. Positive elimination of these two possibilities leaves us with only absorption mechanisms involving polymers and collision-induced dipoles as possible absorption mechanisms. Although we have obtained no evidence which would entirely eliminate the possibility of polymer formation in the liquid state, the results of the Canadian group[2] indicate that the collision-induced dipoles are chiefly responsible for the observed effects and we have obtained no evidence that is in disagreement with this hypothesis.

[1] M. L. Oxholm and Dudley Williams, Phys. Rev. **76**, 151 (1949).
[2] Crawford, Welsh, and Locke, Phys. Rev. **75**, 1607 (1949).
[3] A. L. Smith, W. E. Keller, and H. L. Johnston, Phys. Rev. **79**, 728 (1950).
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## Total Charges of Fission Fragments in Gaseous and Solid Media

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IN earlier experiments[1,2] the total charges of fission fragments emerging into vacuum from a uranium layer were determined by a measurement of the curvature of the paths described by the fragments in the magnetic field of the cyclotron. Recently further experiments have been carried out by means of a new deflection apparatus similar to the earlier one, but constructed in such a manner that the space between the uranium layer and the ionization chamber used for detection could be filled with a gas to any desired pressure. At not too high pressures the variation of the mean charge, $e$, and the velocity, $v$, along the path inside this deflection chamber can be neglected, and at the same time the pressure may be sufficiently high to ensure that equilibrium between capture and loss of electrons by the fragments will be established in the first few millimeters of the path, the entire length of which inside the deflection chamber is 200 mm. In this case the deflection will be proportional to the mean charge of the fragments in the gas considered. If the deflection chamber is evacuated, the deflections will be proportional to the charges of the fragments in the uranium layer, when the latter is uncovered. By covering it with a thin layer of another metal one obtains the charges in this metal. In the same way as earlier,[2] the charges were determined for each of the two groups separately.

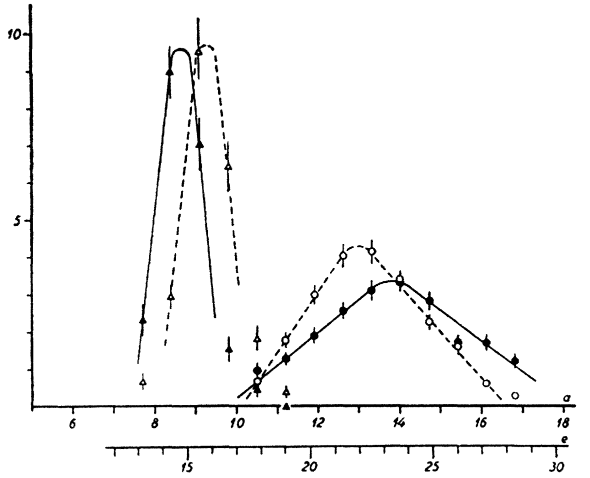

FIG. 1. Distribution of deflection of fission fragments. Abscissa: Deflection $a$ = const. $\times e/mv$. Approximate scale of $e$ below. Circles refer to fragments having traversed a thin Be layer and emerging into vacuum. Triangles refer to fragments emerging into argon at a pressure of 0.9 mm. White and black points correspond to the light and heavy fragments, respectively.

As an example Fig. 1 shows the result of two measurements, one giving the charges in beryllium, the other giving the charges in argon. Only small differences were found between the charges in various solid stopping media or between the charges in various gases, but, as is seen, the charges are much lower in gases than in solids. In gases the light fragment has the higher charge, opposite to what is the case in solids. This order of the charges is in agreement with previous determinations of the effective charges from ionization measurements.[3,4] The latter charges were somewhat higher than the values now obtained, but at least part of the difference may be accounted for as due to a dependence of the charge on pressure, see below. The difference between the widths of the distribution curves in gases and in solids gives an interesting illustration of the fluctuation of the charges. With a gas at a sufficiently high pressure in the chamber many interchanges of charge occur along the path, and the deflection is determined merely by the mean value taken over the part of the range considered.

Figure 2 gives the most frequent deflections obtained for various pressures of argon in the chamber. As mentioned, the initial values of the deflections correspond to the most frequent charges in uranium, and the deflections for a pressure ~1 mm or argon correspond to the equilibrium charges in argon. The rate of decrease of the deflections for increasing pressure between 0 and 0.5 mm is determined by the rate with which the charges decrease due to capture of electrons. The cross sections estimated from the curves are in rough agreement with theory; they are of the order of magnitude $10^{-16}$ cm$^2$.

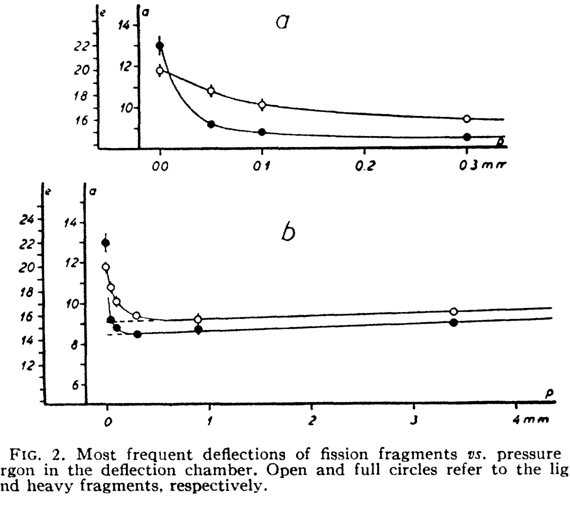

FIG. 2. Most frequent deflections of fission fragments *vs.* pressure of argon in the deflection chamber. Open and full circles refer to the light and heavy fragments, respectively.

The curves are not horizontal for pressures above 1 mm. Since, as was shown by direct measurements, the charge varies in the beginning of the range very nearly proportional to the velocity, the increase of the deflection can only be caused by an increase of $e$ with increasing pressure. The increase is rather small but safely outside the limits of error; it is found for both fragments in a number of gases investigated. An attempt has been made to follow the increase of the charges up to higher pressures. The rate of increase is found to be markedly smaller for $p > 10$ mm of argon. It is planned to examine the charges at much higher pressures.

The experiments reveal a marked difference between the mechanism of electron capture and loss in solid and gaseous materials. In particular, the dependence of the mean charge on gas pressure shows that excited states of the fragment ions with lifetimes comparable with intervals between successive collision play an essential part in the phenomenon. A theoretical treatment of electron capture and loss with special reference to these points will be given in a paper by N. Bohr and J. Lindhard to appear in the *Communications of the Danish Academy of Science.* Also, a detailed paper on the present experiments with a closer discussion of the observations will be published shortly.

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[1] N. O. Lassen, Kgl. Danske Vid. Sels. Math.-fys. Medd. **23**, nr. 2 (1945).
[2] N. O. Lassen, Phys. Rev. **68**, 142 (1945).
[3] N. O. Lassen, Phys. Rev. **75**, 1762 (1949).
[4] N. O. Lassen, Kgl. Danske Vid. Sels. Math.-fys. Medd. **25**, nr. 11 (1949).

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## Improved Map of the Solar Spectrum between 9 and 10μ*

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DURING the mapping program of the infra-red solar spectrum being carried out at the Ohio State University the 9 to 10$\mu$ region has recently been investigated with a 3600-line/inches replica echelette grating and the apparatus described in a previous communication.[1] Figure 1 is a composite diagram of the best records so far obtained, the most prominent absorption in this region being a band of ozone, the center of which occurs near 9.58$\mu$. Comparison with the solar spectrum taken by Adel[2] in this region shows that many lines have now been resolved into doublets.

A weak band of carbon dioxide near 9.4$\mu$ partially overlaps the ozone band and the frequencies of the rotational lines of the band have been measured in the laboratory by Barker and Adel.[3] Many of these lines have also been observed in the solar spectrum by Adel,[4] who found a maximum absorption of eight percent for the strongest lines in spectra taken in December, 1940 at Flagstaff, Arizona.

The observations taken at Columbus, Ohio, with a solar altitude of 60° show a maximum absorption of 20 percent for the strongest lines. Comparison of $CO_2$ lines in our solar spectrum, in regions where there are no other obscuring lines, with the laboratory data of Barker and Adel show a small (0.2 cm$^{-1}$) systematic difference in frequency. In Fig. 1 this difference has been added to the values of Barker and Adel and the frequencies thus obtained are indicated by arrows, the lengths of the arrows giving the relative intensities of the lines.