current as reported by Cobine[2] for carbon. This has also been observed with a cathode-ray oscillograph for an arc fed with superposed alternating and direct current. Transitions in the reignition voltage have been observed for C, Co, Cr, Fe, Mn, Mo, Ni, W and Zn while Cu, Ag, and Al show only a single state over the range of current investigated (0.8–15 amp.).

MAX GARBUNY
LYNN H. MATTHIAS

Allen-Bradley Laboratory,
Milwaukee, Wisconsin,
June 19, 1940.

[1] See J. Slepian, J. A. I. E. E. October, 1928; F. C. Todd and T. E. Browne, Phys. Rev. **36**, 732 (1930).
[2] J. D. Cobine, R. B. Power and L. P. Winsor, J. App. Phys. **10**, 420 (1939).

A Rotational Analysis of Some CS_2 Bands in the Near Ultraviolet System

In considering the possible electron configurations of various electronic states of carbon disulphide, Mulliken concluded that the molecule, though linear in the normal state, is bent in the excited electronic state of the λ3200 absorption band system.[1]

Some time ago Jenkins[2] reported that some of the bands in this system resemble those of a linear molecule with a simple P and R branch. However, with the spectrograph used, many of the lines were not resolved. Photographs of the bands taken by the writer in the second order of a 30,000-line-per-inch grating having a practical resolving power of about 300,000, show some of the bands fairly well resolved. Both parallel and perpendicular types are present. It will be shown by Mulliken in a later paper that even if the molecule is bent in the excited electronic state, one may still expect essentially the same types of band structures as if it had remained linear. Let $\Lambda h/2\pi$ be the angular momentum along the axis in the lower state. In the upper electronic state, the angular momentum around an axis parallel to the line joining the S atoms may be characterized approximately by $Kh/2\pi$, because even a considerably bent carbon disulphide molecule approximates surprisingly closely to a symmetric top. Then there exists for practical purposes a selection rule, $(K-\Lambda)=0$ (parallel type), or ± 1 (perpendicular type).

The results obtained from the analysis of four rotational bands may be summarized as follows:

Band at λ3501, type $^1\Sigma_u^+ \leftarrow {}^1\Sigma_g^+$, $B'=0.1122$, $B''=0.1093$
Band at λ3467, type $^1\Pi_g \leftarrow {}^1\Sigma_u^+$,
$B_{PR}'=0.1044$, $B_Q'=0.106_5$, $B''=0.1016$
Band at λ3637, type $^1\Sigma_u^+ \leftarrow {}^1\Sigma_g^+$, $B'=0.1178$, $B''=0.1151$
Band at λ3601, type $^1\Sigma_u^+ \leftarrow {}^1\Sigma_g^+$, $B'=0.1120$, $B''=0.1097$

The B values are in cm^{-1}. The symbols used for the transition type are not strictly applicable to the bent molecule but represent those linear molecule types which the observed bands resemble. However, the capital Greek letters continue to represent the total angular momentum about the figure axis.

The bands at λ3501 and λ3601 have a common upper state whose rotational levels are perturbed. This perturbation has been analyzed indicating that it is of the heterogeneous type ($\Delta\Lambda=\pm 1$), the observed $^1\Sigma_u^+$ being perturbed by a $^1\Pi_u$ state. The perturbation analysis gives sufficient data to determine that the B value of the perturbing state is 0.113 cm^{-1}. The prediction by the theory that the heterogeneous type of perturbation causes a constant shift of all levels whose J values are greater than those of the perturbed levels, has been verified. The intensity distribution among the perturbed lines and the extra lines introduced by the perturbation has been calculated and verified. The lower states of these two bands differ by two quanta of the degenerate vibration ν_2. This would indicate that the value $\nu_2=397$ cm^{-1}, as given by the Raman spectra data for liquid carbon disulphide, is too low for carbon disulphide vapor.

It will be noted that the band at λ3467 has two B values for the upper state. One was obtained from the Q branch, the other from the P and R branches. This may most reasonably be explained by a splitting of the levels due to the removal of K degeneracy by asymmetry. In order for the asymmetry to be sufficiently large to produce the observed splitting, it is necessary that the apex angle be bent to about 120° in the upper state. Calculations show that in spite of this asymmetry, rotational levels in the upper state will still approximately follow a simple $J(J+1)$ formula if J is less than 25.

LEONARD N. LIEBERMANN

Ryerson Physical Laboratory,
University of Chicago,
Chicago, Illinois,
June 25, 1940.

[1] R. S. Mulliken, J. Chem. Phys. **3**, 720 (1935).
[2] F. A. Jenkins, Astrophys. J. **70**, 191 (1929).

Gamma-Ray Resonances from the Bombardment of Carbon by Deuterons

Gamma-rays from the bombardment of carbon by deuterons were first reported by Lauritsen and Crane.[1] Later Tuve and Hafstad[2] reported γ-rays of high intensity from carbon bombarded by 1.0-Mev deuterons. We have confirmed this high yield of γ-rays from $C^{12}+H^2$ and have further found that the curve of γ-ray intensity as a function of bombarding energy is not a continuously rising curve but exhibits resonances. This is very interesting in view of the fact that it is the first known case of resonant emission of γ-rays from deuteron bombardment. Furthermore the data on the resonances in the emission of neutrons[3] and protons[4] from $C^{12}+H^2$ indicate that the γ-rays, at least in part, come from a radiative capture of a deuteron by C^{12}.

The experiments on the γ-ray resonances have been carried out with the Rice Institute high pressure Van de Graaff machine. The γ-rays have been detected both by means of coincidences of Geiger counters and by a Wulf type electroscope filled with argon at 70 atmospheres pressure. Most of the data have been taken with the electroscope because of the greater reliability and speed of such measurements. The intensity of the γ-rays from one microampere of 1.5-Mev deuterons on a thick graphite target was found to give the same ionization in the argon-filled chamber as 5 mg of radium (filtered by 1 cm of iron). The γ-ray intensity from $C^{12}+H^2$ was found to be three