Microwave Measurement of D_0 for CO†

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The value of D_0 for $C^{12}O^{16}$ was determined as 189.0 ± 0.7 kc/sec from measurements on the $J=0\rightarrow1$ and $J=1\rightarrow2$ rotational transitions. Also, the frequency of the $J=1\rightarrow2$ line was determined as $230\,536.59\pm0.52$ Mc/sec.

FROM the microwave spectrum of the $J=0\rightarrow1$ and $J=1\rightarrow2$ transitions of $C^{12}O^{16}$ the value of D_0 for this molecule has been determined. Also, the frequency of the $J=1\rightarrow2$ transition was determined to a high precision by combining our measurement with the previously measured frequency of the $J=0\rightarrow1$ transition.[1]

Figure 1 shows an oscilloscope picture of the two CO absorption lines. The strong line on the right is the $J=0\rightarrow1$ transition and the weaker line is the $J=1\rightarrow2$ transition. This type of picture was obtained by permitting microwave energy at 1.3-mm and also at 2.6-mm wavelength to pass through the absorption cell simultaneously and be detected by one crystal. The separation between the two lines was measured by frequency modulating the klystron with a calibrated, variable-frequency oscillator to produce sidebands of the strong line. The first sideband was superimposed on the weak line, and the separation was thus given by twice the frequency of the modulating oscillator.[2] (The factor of two is due to the weak line being twice the frequency of the strong one.)

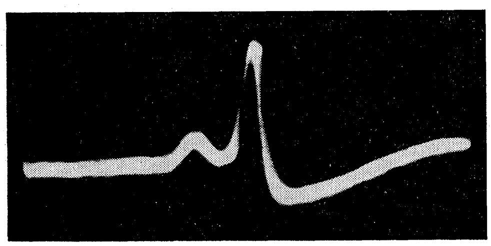

FIG. 1. Oscilloscope picture of the $J=0\rightarrow1$ (right) and $J=1\rightarrow2$ (left) transitions of CO at liquid air temperature. The frequencies of the lines are 115 270.56 and 230 536.59 Mc/sec, respectively.

The microwave energy at 1.3 and 2.6 mm was obtained from a crystal harmonic generator driven by a 1-cm Raytheon klystron. The absorption cell was a 7-foot length of silver waveguide 0.280×0.140 inches in cross section. The measurements were made at liquid air temperature, for which purpose the cell was encased in a brass tube insulated with two inches of styrofoam.

The frequencies of the rotational transitions of a diatomic molecule in the ground vibrational state are:

$$\nu=2B_0(J+1)-4D_0(J+1)^3,$$

where $J=0, 1, 2, \cdots$, $B_0=h/8\pi^2cI_0$, and $D_0=4B_0^3/\omega^2$. From this relation the frequency separation of the $J=0\rightarrow1$ and the $J=1\rightarrow2$ lines comes out to be $24D_0$. The measured value of $24D_0$ obtained in this experiment is 4.535 ± 0.016 Mc/sec, thus giving a value of 189.0 ± 0.7 kc/sec or $(6.30\pm0.03)\times10^{-6}$ cm^{-1} for D_0. This value is in fair agreement with $D_0=6.4_5\times10^{-6}$ cm^{-1} obtained by Herzberg and Rao[3] from infrared data.

The frequency of the $J=1\rightarrow2$ transition was found to be $230\,536.59\pm0.52$ Mc/sec by subtracting our value for $24D_0$ from twice the measured frequency of the $J=0\rightarrow1$ line (given as 115 270$\pm$0.25 Mc/sec in reference 1).

The measurement of D_0 is of value in the determination of the velocity of light by the method used by Rank[4] of Pennsylvania State College.

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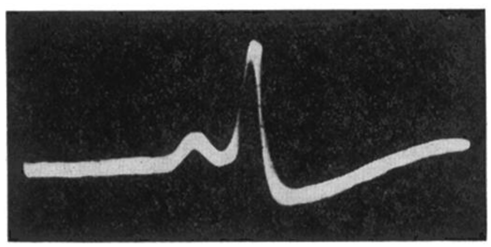
[1] Gilliam, Johnson, and Gordy, Phys. Rev. **78**, 140 (1950).

[2] Dailey, Kyhl, Strandberg, Van Vleck, and Wilson, Phys. Rev. **70**, 984 (1946).

[3] G. Herzberg and K. N. Rao, J. Chem. Phys. **17**, 1099 (1949).

[4] Rank, Ruth, and Vander Sluis, Phys. Rev. **86**, 799 (1952).



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