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THE STRENGTHS OF ABSORPTION LINES IN THE 2-0 BAND OF CARBON MONOXIDE

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The Strengths of Absorption Lines in the 2-0 Band of Carbon Monoxide

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A new determination of the strengths of absorption lines in the 2-0 band of CO has been carried out. Very recently the strengths of lines in this band were reported by Kostkowski and Bass(1), and also briefly by Benedict et al.(2). The present observations were made with better spectral resolution than the ones made by these workers. The spectrometer was a 5-m grating instrument used in double pass.(3) The spectral slit width used was about 0.07 cm^{-1}. The studies were made with gas at approximately atmospheric pressure, and with sample lengths varying from 1 to 30 cm. The sample temperature was 300°K.

The observed line widths were between 0.05 cm^{-1} to 0.10 cm^{-1}. Under these conditions the instrumental slit corrections(4) to the strengths amount to no more than 3 per cent. Since this was within the experimental error, no instrumental corrections were applied and the strengths were obtained by direct integration. It was estimated that wing corrections amounted to one or two per cent at most and they were therefore neglected.

Using the notation of Benedict et al.(5), the strength S_m^o per unit gas pressure of an individual line is given by

$$S_m^{\,o} = S_{2-o}^{\,o}\frac{F_m|m|\nu_m e^{-E(J)/kT}}{Q(T)\bar{\nu}} \quad . \qquad (1)$$

Here $Q(T)$ is the rotational partition sum ($Q(300) = 108.86$) and $\bar{\nu}$ the effective vibrational frequency(5) ($\bar{\nu}_{2-o} = 4282.1$ cm^{-1}). The exponential factors were calculated from the accurately known(6,7) spectroscopic constants of CO. F_m expresses the effect of the vibration-rotation interaction. It may be written for the present case, according to Herman and Wallis(8), to the first order in m, as follows:

$$F_m = 1 + (0.00528 - 0.0075\,\theta)m$$

where $\theta = M_o/M_1 r_e$; M_o and M_1 are the first two coefficients of a Taylor-series expansion about the equilibrium internuclear distance r_e of the dipole moment function

$$M = M_o + M_1(r - r_e) + \ldots,$$

M_o is almost equal to the permanent dipole moment (0.117 debye(9)), and a good approximation for M_1 may be calculated from the strength of the 1-0 band(2) (214.8 cm^{-2}atm^{-1}). The value of r_e is obtained from the rotational constant(7), B. The resulting approximation to the absolute value of θ is then 0.036. Without loss of accuracy, θ has been taken equal to zero, and the vibration-rotation interaction term may then be written as

$$F_m \sim 1 + 0.00528m.$$

Fig. 1 shows the line strengths of the present work together with those obtained by Kostkowski and Bass(1). The value of the band strength $S_{2-0}{}^{0}$ which gives the best fit to the experimental points was found to be 1.51 $cm^{-2}atm^{-1}$ at 300°K. The curve corresponding to equation (1) with $S_{2-0}{}^{0} = 1.51$ $cm^{-2}atm^{-1}$ is also shown. It is seen that the line strengths obtained in the present work are lower than those given by Kostkowski and Bass(1), whose measurements correspond to a band strength of 1.77 $cm^{-2}atm^{-1}$. Benedict et al.(2) give $S_{2-0}{}^{0} = 1.5$ $cm^{-2}atm^{-1}$, in good agreement with the present value. On the other hand, Penner(10), by a direct determination, obtained a band strength of 1.64 $cm^{-2}atm^{-1}$.

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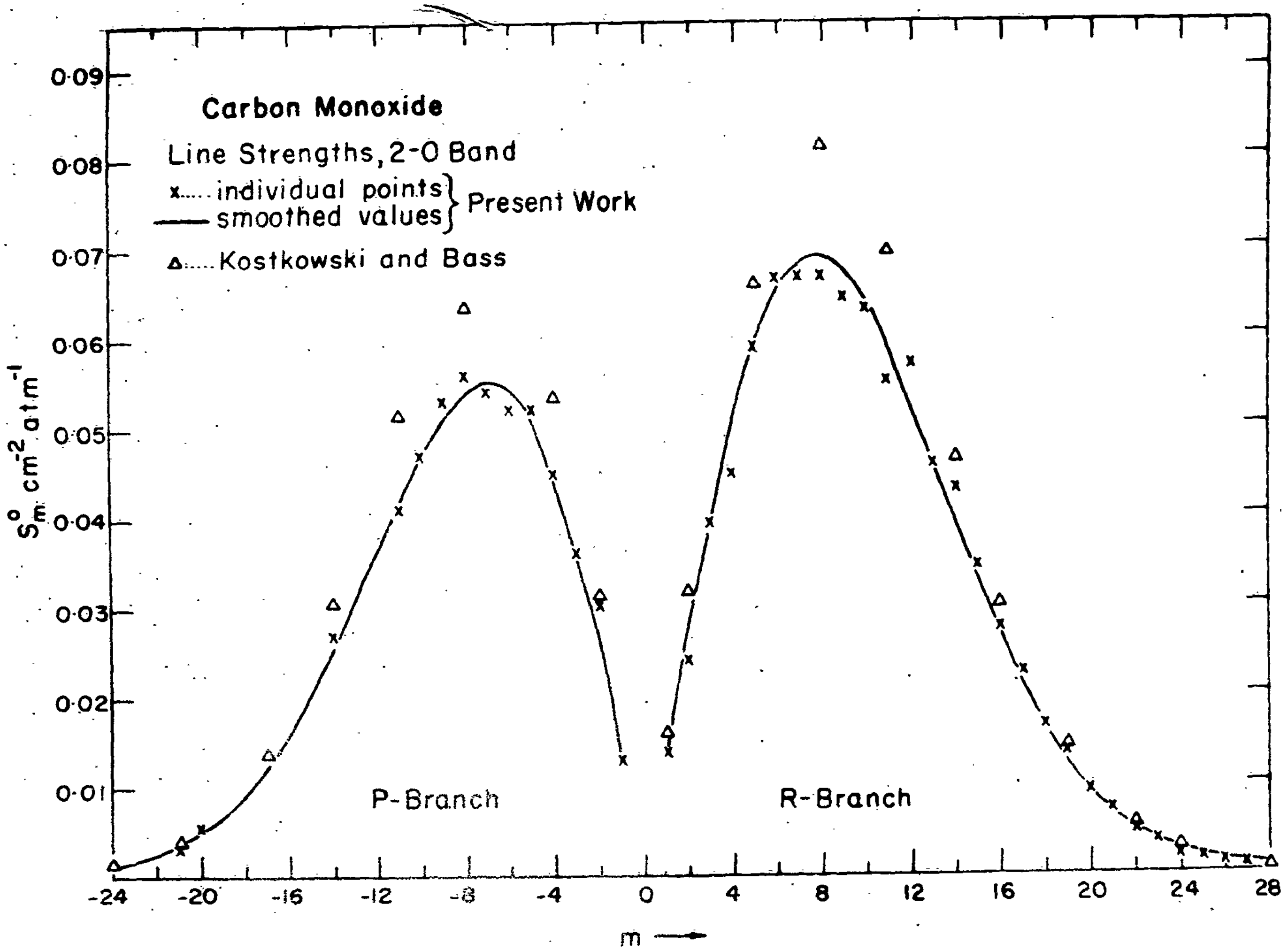

Fig. 1 Carbon monoxide line strengths in 2-0 band at 300°K.