# THE DISTORTION DIPOLE ROTATIONAL SPECTRUM OF $CH_4$: A LOW TEMPERATURE FAR-INFRARED STUDY

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The perturbation-allowed distortion moment spectrum of $CH_4$ has been studied between 20 to 100 $cm^{-1}$ with a Fourier transform spectrometer at a temperature of 113.5 K similar to that in the atmospheres of Saturn and Titan. Data were obtained at a resolution of 0.06 $cm^{-1}$ and of 0.24 $cm^{-1}$ with a sample gas pressure of 794 Torr using an absorption path length of 60.0 m. For each $(J+1 \leftarrow J)$, the tetrahedral fine structure was blended together into a single $R(J)$ envelope. Six such envelopes for $J = 3$ to 8 were measured, the strongest having a signal-to-noise ratio ~80. From an intensity analysis of $R(5)$, $R(6)$, and $R(7)$, the distortion dipole moment $\mu_D$ of methane was determined to be $23.82(0.88)$ and $23.94(1.20)$ $\mu$D from the low and high resolution spectra, respectively, in excellent agreement with earlier less precise intensity measurements at room temperature and the value of $24.06(0.45)$ $\mu$D obtained from the Stark effect by I. Ozier, Phys. Rev. Lett. 27, 1329 (1971). Based on these results, it is recommended that the intensities for these transitions in the HITRAN/GEISA data bases be scaled upward by a factor of 1.154. This line spectrum arising from centrifugal distortion mixing was superimposed on a broad continuum due to collision-induced translation-rotation transitions. This continuum was measured from 20 and 180 $cm^{-1}$ (with a gap between 100 and 120 $cm^{-1}$), and is compared with the theoretical model of A. Borysow and L. Frommhold, Ap. J. 318, 940 (1987) at a lower temperature and with higher absolute accuracy than previously possible. Two features near 125.6 and 157. 3 $cm^{-1}$, each ~5 $cm^{-1}$ wide, are seen to arise from rotational transitions in $CH_4-CH_4$ dimers. The study of the distortion dipole spectrum has direct application to the measurement of the $CH_4$:$H_2$ ratio and the temperature structure in the atmospheres of the Giant Planets and Titan.