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

E. H. WISHNOW, *Space Sciences Laboratory, University of California, Berkeley, CA 94720; and Department of Physics and Astronomy, University of British Columbia, Vancouver, BC, Canada V6T 1Z1*; G. S. ORTON, *Jet Propulsion Laboratory, Pasadena, CA 91109*; I. OZIER, *Department of Physics and Astronomy, University of British Columbia, Vancouver, BC, Canada V6T 1Z1*; H. P. GUSH, *Department of Physics and Astronomy, University of British Columbia, Vancouver, BC, Canada V6T 1Z1*.

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 μ_D of methane was determined to be 23.82(0.88) and 23.94(1.20) μD 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) μD 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.