

HIGH RESOLUTION LABORATORY SPECTROSCOPY OF ETHANE (C₂H₆) AT 35 μm (289 cm⁻¹)

N. Moazzen-Ahmadi¹, J. Norooz Oliaee¹, I. Ozier², E. H. Wishnow³,
K. Sung⁴, L. R. Brown⁴, T. J. Crawford⁴ and V. M. Devi⁵

¹Dept. of Physics and Astronomy, University of Calgary, Calgary, AB, T2N 1N4, Canada

²Dept. of Physics and Astronomy, University of British Columbia, Vancouver, BC, V6T 1Z1, Canada

³Space Sciences Lab, University of California, Berkeley, CA 94720, U.S.A.

⁴Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, U.S.A.

⁵Dept. of Physics, The College of William and Mary, Williamsburg, VA 23187, U.S.A.

Introduction:

Ethane is the second most abundant hydrocarbon detected in the outer planets. Although the lowest fundamental at 35 μm is very weak by laboratory standards, this torsional mode is easily observed in the CASSINI/CIRS spectra of Titan. Reliable line intensities are required for accurate characterization of far-infrared observations. The prior studies [1,2] have been extended to the lower temperatures more characteristic of the outer planets.

Experimental details:

The torsional mode (ν_4) of C₂H₆ and its first hot band ($2\nu_4-\nu_4$) are being characterized from 220 to 330 cm⁻¹ for planetary remote sensing. Seven high resolution (0.01 and 0.02 cm⁻¹) laboratory spectra were obtained with a 52 m path using a cryogenic multi-pass absorption cell [3] coupled to the Bruker IFS-125 spectrometer at the Jet Propulsion Laboratory. Because this torsional band is very weak, sample pressures up to 254 Torr (0.34 bar) were required. The gas temperatures ranged from 293 K to 166 K; the lower temperatures are relevant to the stratosphere of Titan.

An example of the observed spectrum is shown in the upper frame of Fig. 1.

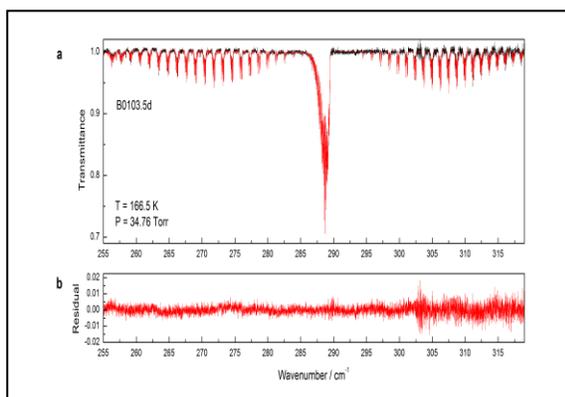


Fig. 1. Ethane (C₂H₆) absorption at 35 μm. a) observed C₂H₆ FT-IR spectrum (black) overlaid by the predicted spectrum (red). The gas conditions are 34.76 Torr at 166.5 K with an optical path length of 52 m. b) obs. – pred. spectral differences.

Analysis and conclusion:

Intensities were analyzed to obtain dipole moment and interaction parameters using direct comparison of the observed cold spectra with predicted line positions and intensities. Coefficients in the quantum mechanical model were iteratively adjusted until spectral residuals were minimized. Higher order Coriolis interaction terms were required to obtain the satisfactory fit seen in Fig. 1 for the whole band and in Fig. 2 for the Q branch. These new results will lead to a better characterization of ethane and in turn an improved understanding of the methane cycle in planetary atmospheres.

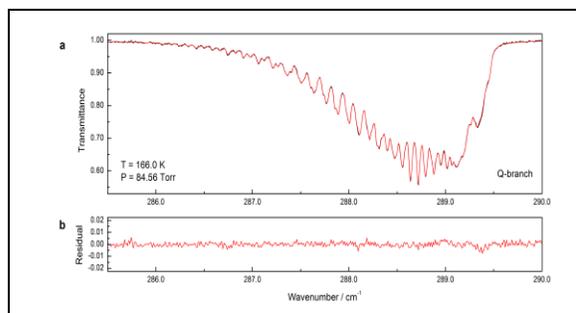


Fig. 2. The ν_4 Q branch of C₂H₆ (84.56 Torr at 166 K and a 52 m path). Other weak bands were also assigned. a) Black: obs.; red: pred. b) obs. – pred. spectral differences.

Acknowledgements:

The research conducted at the University of Calgary is supported by the Canadian Space Agency. Part of the research described in this paper was performed at the Jet Propulsion Laboratory, California Institute of Technology, and The College of William and Mary, under contracts and cooperative agreements with the National Aeronautics and Space Administration.

References:

- [1] Moazzen-Ahmadi N., McKellar A.R.W., Johns J.W.C. and Ozier I. (1992) J. Chem. Phys. 97, 3981-3989.
- [2] Moazzen-Ahmadi N. (2002) J. Mol. Spectrosc. 214, 144-151.
- [3] Wishnow E. H., A. Leung A. and Gush H. P. (1999) Rev. Sci. Instru. 70, 23-31.