# NEW INFRARED SPECTRA OF THE JOVIAN PLANETS: STUDY OF JUPITER AND SATURN IN THE $3\nu_3$ METHANE BAND BY FOURIER TRANSFORM SPECTROSCOPY

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**Abstract.** High resolution spectra of Jupiter and Saturn were obtained with a Fourier Transform Michelson interferometer. A comparison of the observed spectra, after elimination of the solar and terrestrial contributions to absorption, with synthetic profiles for the reflecting layer model has permitted new determinations of the Lorentz half-width, the methane abundance, the rotational temperature and the pressure at the level of formation of the methane lines for both Jupiter and Saturn.

We recorded high-resolution spectra of Jupiter and Saturn from 4000 to 12000 $cm^{-1}$, respectively, in May and December 1972, with a Fourier Transform Interferometer at the 193 cm telescope of the Haute Provence Observatory (France). The resolution obtained is 0.22 $cm^{-1}$ for the Jupiter spectrum and 0.26 $cm^{-1}$ for the Saturn spectrum. Spectra of the Sun and the Moon were also recorded for comparison. For both planets the region of the *R*-branch of the $3\nu_3$ methane band 9050–9150 $cm^{-1}$ has been analysed in order to determine the average Lorentz half-width, the abundance of methane, the rotational temperature and the pressure at the level of formation of the methane lines.

The equivalent widths and the average Lorentz half-width (assuming that all lines had the same half-width) were deduced from a comparison of synthetic profiles of the methane *J*-manifolds with the observed ones ($R(0)$ to $R(7)$), after the elimination of telluric and solar absorptions. The wavenumbers of the *J*-manifolds used in the computations were determined accurately by recording laboratory spectra of $CH_4$ at 0.02 $cm^{-1}$ resolution. The rotational temperature and abundance of methane were then obtained by using the method of Margolis and Fox (1969a, b), assuming that the reflecting-layer model was appropriate. The air-mass factor $\eta$ was taken equal to 2.5 for Jupiter and 2.8 for Saturn. The results obtained are shown in Table I.

The continuum level used to do the analysis was defined by comparing maxima of Jupiter and Saturn spectra with maxima of the solar spectrum in a large spectral range (9000–9500 $cm^{-1}$), which permitted us to find a continuum gaseous absorption in the $3\nu_3$ region. Dipole-induced hydrogen absorption (2–0 band) is probably responsible for the observed increase in absorption from 9300 $cm^{-1}$ towards lower wavenumbers. Indeed, it was found that, by using laboratory absorption coefficients of hydrogen (Hunt, 1959; Welsh, 1969) for the temperature range considered, 28 to

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TABLE I

Average Lorentz half-width, rotational temperature, abundance of methane and effective pressure of the $R$-branch of the $3\nu_3$ methane band for Jupiter and Saturn

| Jupiter | Saturn |
| --- | --- |
| $\gamma_{\text{average}} = 0.10 \pm 0.03\ \text{cm}^{-1}$ | $\gamma_{\text{average}} = 0.15 \pm 0.03\ \text{cm}^{-1}$ |
| $T_{\text{rotational}} = 150 \pm 15\ \text{K}$ | $T_{\text{rotational}} = 134 \pm 15\ \text{K}$ |
| $\eta a = 95 \pm 20$ m-atm | $\eta a = 118 \pm 30$ m-atm |
| $a = 38 \pm 8$ m-atm | $a = 42 \pm 11$ m-atm |
| $P_{\text{effective}} = 1.0 \pm 0.3$ atm | $P_{\text{effective}} = 1.3 \pm 0.3$ atm |

48 km-atm of hydrogen (depending on the ortho-para hydrogen ratio) in the Jupiter atmosphere would explain the pseudo-continuum absorption which shows up in the range 9300–9000 $\text{cm}^{-1}$. For Saturn, the upper limit for the hydrogen amount is 54 to 92 km-atm. The results shown in Table I correspond to such an amount of hydrogen absorption.

$^{13}CH_4$. In the region of the $R$-branch of the $3\nu_3$ band of $^{12}CH_4$ we have detected absorption lines which cannot be $^{12}CH_4$, telluric or solar lines, and appear precisely at the wavelengths of the $R(2)$, $R(3)$ and $R(6)$ lines of $^{13}CH_4$ $3\nu_3$ band of the laboratory spectrum recorded by Pugh, Owen and Rao (Stony Brook).

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## DISCUSSION

*Trafton:* What is the basis of your estimate that 28–48 km-amagats of $H_2$ exists above the reflecting layer?

*De Bergh:* I assumed several abundances, and chose the one which gave the observed distortion to the continuum in the $3\nu_3$ $CH_4$ region.

*Traub:* Can you deduce an ortho-to-para hydrogen ratio for Jupiter from your spectra?

*De Bergh:* The estimates on hydrogen abundances we get depend on the ortho-para hydrogen ratio, and it is certainly not possible to deduce the ortho-para ratio from our spectra only.

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