H_2-Broadened $H_2{}^{16}O$ in Four Infrared Bands between 55 and 4045 cm-'

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(for J. Q. S. R. T.)

Abstract

To support the remote sensing of the outer planets, absorption spectra of H_2O broadened by H_2 were recorded at room temperature using two Fourier transform spectrometers. The data from 1260 to 2070 cm-l and 3420 to 4045 cm-' were obtained at 0.0056 and 0.012 cm-l resolution (unapodized), respectively, with the McMath FTS located at Kitt Peak National Observatory / National Solar Observatory. The remainder of the spectral data from 55 to 328 cm"' was taken at 0.0056 cm-l with the HR120 Bruker FTS at the Jet Propulsion Laboratory. Some 630 Hz-broadened linewidths of $H_2{}^{16}O$ were obtained with precision of 2% to 7% for the four strongest water bands: rotational at O. cm-*; ν_2 at 1595 cm-l; ν_1 at 3657 cm-l and ν_3 at 3756 cm'l. The intensity of the weakest measured transition was 0.0065 cm^{-2}/atm at room temperature. Within a band, the widths varied from 0.101 cm^{-1}/atm to 0.033 cm^{-1}/atm at room temperature for O.-J $\leq$ 12 and O $\leq$ Ka $\leq$ 6. Systematic patterns were detected in the widths as a function of AJ, J, Ka, and asymmetry. At low Ka, the widths decreased with increasing J, but for Ka > 2, the widths generally increased with increasing J. Examination of the vibrational dependencies of the three perpendicular bands also revealed that the widths of the V_2 and rotational transitions were nearly the same (within 3$%), but the widths of ν_1 wei e generally larger (up to 18%). The limited width measurements reported by others in the pure rotational and 1.4 μm regions supported the conclusions concerning vibrational dependencies,

Introduction and Experimental Details

The broadening of water by hydrogen was so little studied that the only previous experimental results were the two separate measurements of a pure rotational transition at 22 GHz by Liebe and Dillon[1] in 1969 and Kasauga et al.[2] in 1978 and the studies over a range of temperatures for the two transitions at 183 and 380 GHz by Dutta et al.[3] in 1993 and eleven transitions at 1.4 μm by Langlois et al.[4] in 1994. Three rotational transitions of hydrogen-broadened HDO near 230 GHz were also measured by Goyette et al.[5] The rotational transitions of H_2O were 'R$_2$ for J" = 2, 3 and 5, and their observed broadening coefficients were all close to 0.08 cm-$^{1/}$ at m at room temperature while the 1.4 μm transitions were mostly Q branch lines for J" = 1 - 5, Ka = 1 -3 for which the widths ranged from 0.067 to 0.123 cm^{-1}/atm. The present measurements of broadening coefficients were undertaken to support of the remote sensing of Jupiter's atmosphere by the Net Flux Radiometer experiment on the Galileo spacecraft. The primary objective was to determine the variation of widths in the ν_2 band in the important 5 μm window region. Widths were also obtained for the rotational region and the other fundamentals so that vibrational dependence of widths could be investigat ed. In a continuing effort, Gamache is pursuing theoretical modeling of the line widths[7].

The experimental conditions of the laboratory spectra used for this project are summarized in **Table 1** which gives the bandpass, instrument, resolution, integration times of a spectrum, detectors, optical paths and sample pressures of H_2 and H_2O. **Figure 1** shows a compressed plot of the ν_2 region to illustrate the quality of the spectra. The data were recorded with the Fourier transform spectrometer at the McMath telescope located at Kitt Peak and the Bruker FTS at the Jet Propulsion Laboratory using three different detectors (bolometer, As-doped Si and InSb) and beamsplitters (mylar, KCl and CaF_2). With the Kitt Peak FTS, two stainless steel absorption cells (1.5 m and 0.25 m) were placed between the globar source and the FTS chamber, and all portions of the external path and the source enclosure were evacuated using some newly-installed apparatus; the effective pressures were 4 Torr for the 2.7 μm region and 1 Torr for the 6 μ region. For the rotational lines, a glass absorption cell was placed inside the Bruker's sample compartment, and the interior of the Bruker was evacuated by a cryopump to less than 0.02 Torr. Line widths (Half Widths at Half Maximum) were obtained from 18 different spectra whose hydrogen pressures ranged from 85 Torr (11.3 kPa) to 993 Torr (132 kPa). Pressures were monitored continuously during the scanning by capacitance gauges accurate to 0.5% or better, and the gauges were checked against local atmospheric pressure (600 Torr) determined with a Hg manometer. Temperatures were obtained with thermistors in thermal contact with the exterior of the absorption cells. All the data recorded with the Bruker were obtained with dilute mixtures of NH_3 and H_2 in which the water appeared as an impurity inside the absorption cell,[8] For the Kitt Peak data, distilled "normal sample" water was mixed with ultra-pure grade hydrogen in the absorption cell. Optical densities were chosen so that widths of the strongest vibrational bands of $H_2{}^{16}O$ could be measured. Only widths of lines with intensities greater than 0.0065 cm^{-2}/ atm at 296 K were obtained.

The widths were retrieved from the spectra using a non-linear least-squares curve-fitting technique which adjusts the assumed values of positions, intensities and widths in the calculated spectrum to minimize the differences between the observed and synthetic spectra[9]. The initial calculated positions, intensities and self-broadened widths were taken from the 1992 HITRAN database[10], and the self-broadened widths were held fixed. In the Kitt Peak data, there was some residual water inside the FTS enclosure, but the extra features from this were effectively modeled during the retrieval by fitting each water line as two components, as shown in the upper frame of **Fig. 2; while** the presence of the residual lines permits line shifts to be measured, these are not being reported at this time. in many cases, lines overlapped enough that several transitions had to be measured simultaneously, as illustrated in lower portion of **Fig. 2**. Measurements of blended features were generally not attempted unless they were required to obtain values for adjacent lines. For each spectral feature, the Hz-broadened H_2O width, position and relative intensity were obtained as averages based on three to twelve spectra, The relative intensities from each run were normalized to the values in the HITRAN database[10] so that the effective partial pressures of H_2O could be determined (see **'I'able 1). The** %rms agreement between the individual retrievals and the ratio of the calculated to observed intensities were used to assess data quality. Values were omitted from consideration if a) less than three spectra were used b) the rms values were greater than 7% or c) the observed line intensity was different from the calculated value[10] by more than 15% **Table 2** summarizes the resulting measurements by giving the vibrational band and its band center in cm^{-1}, the number of transitions measured, maximum values of the J and Ka quantum numbers and the effective temperatures in each region,

Other studies[8,11] done with the JPL Bruker and Kitt Peak spectrometers produced line widths that were clearly precise to *3910 or better, and so it is thought that the present data have similar precision. Some indication of the absolute accuracy was obtained by comparing the observed widths of the 16 transitions between 1800 and 2000 cm^{-1} that were measured with two different resolution and detectors at Kitt Peak. The average ratio of the widths at 291 K obtained with the InSb detectors to the widths at 299 K measured with the As-Si detectors was 1.024 (* 3%). The fact that the two sets of widths were done at an 8° difference in temperature potentially complicated this comparison since the exact temperature dependence as a function of the rotational quantum numbers is not known. However, Dutta et al.[3] study observed a temperature dependence coefficient of n = 0.95 and 0.85 for two transitions, and Langlois et al.[4] reported 11 values ranging from n = 0.25 to 1.50. Application of an averaged temperature coefficient of n = 0.7 to normalize the widths in the 1800-2000 cm^{-1} region to a common temperature changed the above ratio to 1.005, indicating that there were no important systematic differences in the accuracies of the fundamental widths. Of course, absolute accuracies are ultimately confirmed through the remeasurement of the same transitions by different investigators. Since the study of NO widths[11] with the Kitt Peak FTS produced values that were within 1% to 4% of results obtained by Ballard et al.[12] with a Bomem FTS, it is expected that an ideal theoretical model will reproduce the bulk of the present H_2- H_2O coefficients to 4% or better.

Results and Discussion

In **Table 3,** some **630** H_2-broadened linewidths (H WHM) of H_20 and the %rms agreement are shown along with the calculated positions[10], the normalized intensities and %rms in parenthesis and the ratios of the calculated / observed intensities. The observed widths are not normalized to 296 K. The last column shows the number of optical densities used to obtain the widths; those involving more than seven spectra are the ν_2 values from different detectors which have been combined without regard to the temperature differences. The broadening coefficients are sorted by increasing values of J and Ka to show that the broadening coefficients vary greatly with quantum numbers. The vibrational bands are indicated by integers O --> 3 corresponding respectively to the rotational, ν_1, ν_2, and ν_3 bands. All but 45 of the widths are for allowed transitions with ΔKa = O or ± 1.

A clearer understanding of the variation of the widths is seen by selecting specific types of transitions. In linear molecules, pairs of transitions have nearly the same widths[11]. For example, the widths of P 8 and R 7 are similar because these transitions involve the same rotational quantum numbers; P 8 is J" = 8 --> J' = 7 and R 7 is J" = 7 --> J' = 8. In the same way, water transitions are predicted to have same widths[7,10] if they involve the same rotational pairs of (J, Ka, Kc); the width of (7,3,4) -> (8,3,5) is expected to be similar to the width of (8,3,5) --> (7,3,4). To test this assumption in the present data, the ratios of 79 pairs of widths in the parallel ν_1 band and the perpendicular band ν_3 were computed and plotted in Fig. 3 as a function of the maximum J in the transition. The average ratio of these is 0.9977 ± 3.4%, indicating that this aspect of the theory is correct. It also provides another verification of the measurement precision.

This comparison suggests that one way to examine the rotational behavior of the widths is to view them as a function of the maximum J and Ka in each transition, rather than J“ or Ka” (in the above transition this would be jm = 8 and km = 3). In Fig. **4,** the observed widths from all bands are plotted as a function of km (Ka maximum) with jm (J maximum) as the plot symbol; they are seen to vary from 0.101 to 0.033 cm^{-1}/atm. The term (km-jm) is used to offset the plotting symbol and reveal certain trends in the data. For example, at low km, the widths decrease greatly with increasing jm, while at the highest km, the widths appear to be increasing with increasing jm. At intermediate km values, the patterns are not clearly seen in this composite display (nor in similar plots involving widths of just one band). However, plots of much smaller subsets of the data do reveal other systematic patterns. For example, the water molecule is an asymmetric rotor. If it were deformed into a symmetric top, then pairs of its transitions would become degenerate, and one might expect their widths then to be the same. However, comparison of the measured widths reveals that the asymmetry of the energy level has a pronounced effect on the size of the widths. **Figure 5** shows some of the observed widths for km = 2 of ν_2 and ν_3 displayed as a function of jm. The symbol “O’ is used for the transition in which Ka + Kc-J = O in both the upper and lower states. The symbol “l” is used for the other line of the symmetric top pair in which Ka + Kc-J = 1 in the upper and lower states. The Q branch transitions of the perpendicular ν_2 band and the R and P branch lines of the parallel ν_3 band are plotted because these types of transitions go between levels of the same symmetry, as illustrated by the diagram in **Fig.** 5. In both bands, the transitions arising between the lower levels of the asymmetry doublets have smaller widths at moderate J, although the pairs seem to be converging at higher J. Although not plotted, the widths of the ν_3 Q branch transitions fall midway between the widths of the asymmetry pairs because the Q type lines arise between the Ka + Kc-J = O and Ka + Kc-J = 1 levels, as illustrated on Fig. 5. When transitions of the same symmetry are grouped together, the variation of the widths as a function of the quantum numbers is more apparent. Figure 6 shows the widths of ν_3 P and R lines (top) and ν_2 Q branch lines (bottom) for which Ka + Kc-J = 0 in both the upper and lower states. The plot symbols are the values of km, and curves are drawn to connect widths of the same km, While not all the points lie on smooth curves, some patterns are apparent. For km = O and 1, the widths drop sharply with increasing jm. For km = 2, widths are still decreasing, but for km = 3, the widths both increase and decrease with increasing jm. For km = 4 and 5 in ν_3, the widths increase faster with increasing jm. One finds similar trends are seen in the other groupings of transitions (1 --> 1, 0--> 1). While it has been helpful to organize the widths in this manner, it is emphasized that jm and km are not true quantum numbers. The widths of the same jm, km do have different values depending on the transition selection rules. Attempts to model these data with empirical expansions in jm and km (of the type used or suggested in other studies[8,13]) failed to reproduce the measurements to within experimental errors; typical observed minus calculated rms values were 15 to 25% with maximum deviations of nearly 200% at low J, Ka.

In a recent review of all existing water linewidths, Gamache et al.[14] noted that the composite database of some 4000 width measurements with different broadeners appeared to contain so many experimental inconsistencies that clear conclusions could not be reached about the vibrational dependence. The present study has avoided this deficiency by obtaining 440 Hz-broadened H_2O widths with consistent accuracies for three different perpendicular bands (rotational, ν_2 and ν_1). For a composite comparison, the ratios of the widths for transitions with exactly the same rotational quanta are computed with the widths of ν_2 in the denominator. The ratios of the pairs arc plotted in **Fig. 7 as** a function of jm + 0.1 (jm -km). For the 51 selected pairs of rotational/ V_2 transitions, the widths are the nearly the same; the rms ratio is 1.016 (t 2.6%). However, for 63 pairs of ν_1 / ν_2 transitions, the widths of the ν_1 band region are larger by as much as 18% compared to the widths of V_2, and the averaged ratio is 1.08 (t 4%). These differences are too large to be caused by experimental error. For the planetary applications, this implies that the same widths can be applied to the important 5 μm and microwave/rotational regions, but for the higher vibrational states, state-dependent models must be used whenever more accurate widths are needed because the rotational dependence is slightly different from band to band.

Finally, the previous[1-4] and present measurements of H_2-broadened H_20 widths are contrasted for different bands. In **Table 4,** no direct comparisons for pure rotational transitions with exactly the same rotational quantum numbers can be done because the 'R type transitions at 22, 1.83 and 380 GHz are too weak in the present infrared data. Two secondary comparisons can be made by using the corresponding transition with the rotational quantum numbers reversed (since theory and observations both indicate these should have similar widths). As seen in **Table** 4, the prior measurement[3] supports the conclusion that there is little vibrational dependence between the rotational and lowest fundamental lines; the ratio of the rotational / V_2 transition widths is 1.002. The comparison of the v $_1$ / rotational widths is less conclusive because the two prior measurements[1,2] disagree by so much. In Table 5, the eleven measurements of Langlois et al.[4] for $\nu_1 + \nu_3$ and $2\nu_1$ are listed with the corresponding measurements of ν_1, ν_2 and ν_3 from the present study. Pairs of transitions involving the same rotational levels (with upper and lower states reversed as in Fig. 3) are grouped together to provide validation of the measurement precision. The observed widths are in units of cm-l / atm at the temperature shown. Langlois et al. also reported experimental values for the temperature dependence of the 1.4 μm transitions, but these have not been applied. The last column in **Table 5 is** the ratio of observed widths. The denominator is the width of the lowest state (ν_2 or ν_3). For the paired transitions, the average of the two widths is used for the ratio. All but one of the 1.4 μm transitions are compared in this manner, and in all ten cases, the widths of the higher vibrational states are larger. In the last three groups involving the three perpendicular bands, the ν_2 widths at 6 μm have the smallest value and $2\nu_1$ at 1.4μm the largest. Thus, the 1.4 μm data also support a conclusion that the widths are vibrationally dependent.

This result is contrary to the prevailing premise. In their comprehensive review of widths measurements, Gamache et al.[14] averaged widths of different vibrational states together to assess the accuracies of available experimental data, and the tacit assumption of no vibrational dependence may have resulted in a pessimistic judgment about the experimental data set for water. In the HITRAN[10] database, the same sets of calculated linewidths for parallel and perpendicular transitions are applied to all the water bands (although individual measurements are inserted if available). This presumption of small vibrational dependence[14] potentially introduces systematic errors into the air- and self-broadening coefficients that can degrade the monitoring of the terrestrial troposphere, since width errors propagate on a one-to-one basis in retrievals[15]. Thus, the vibrational dependencies must be further investigated for N_2- and O_2-broadening by obtaining accurate widths in several bands, as has been achieved in the present effort for Hz-broadening.

Tables 4 and 5 illustrate the fallacy of having limited empirical data. The three pure rotational measurements have such similar values that some might conclude falsely that widths of hydrogen-broadened water are nearly constant. The eleven 1.4 μm measurements indicate a greater rotational dependence, but too few transitions have been measured to verify experimental precision or to see some important rotational behavior in the widths. While the limited studies may provide some insight into fundamental processes, a comprehensive understanding and the good theoretical modeling will not be attained until there is an ample sampling of reliable measurements to guide scientific judgment.

Conclusion

The present extensive set of measurements of H_2- broadened widths is now available for the four strongest vibrational bands of H_2O. The experimental precision are demonstrated to be from 2 to 7% by the rrns agreement between individual scans, and by the fact that the ratios of widths are close to 1.00 for a set of transitions measured by two different detectors and for sets of transition pairs in the same band that are expected from theory to have the similar values. These experimental data reveal the behavior of the widths with the quantum numbers up to J equal 12 and Ka equal 6. Within a band, the widths vary by a factor of three, and the variation is a complex function of the asymmetry and transition selection rules. There is also a vibrational dependence in the widths. The widths of ν_2 and the rotational region are almost the same, but the widths of ν_1 band are generally larger by as much as 18%. Comparison with eleven widths at 1.4 μm also reveals that the line widths are larger for two higher vibrational states. This implies that widths must be measured and modeled for individual bands of interest if accurate widths are needed. Until these data can be reproduced by theoretical modeling, the measured widths are reliable values for planetary studies requiring H_2 - broadened H_2O.

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TABLE TITLES

Table 1 Experimental conditions

Table 2 Distribution of the measured Hz-broadened H_2O widths

Table 3 Observed Hz-broadened widths of $H_2{}^{16}O$ in Four Bands

Table 4 Comparison with the pure rotational width measurements

Table 5 Comparison with the $1.4\mu m$ width measurements

footnote for Table 2

$^+\nu_2$ widths obtained from more than 7 spectra are at an effective temperature of $\approx$ 295 K.

footnote for Table 3

$^+$Positions and intensities are in units of cm^{-1} and cm^{-2}/atm at 296 K respectively. The Hz-broadened widths are in units of cm^{-1}/atm at the effective temperatures ascribed by the vibrational identification: O = rotational region at 29S K, 1 = ν_1 at 291 K, 2 = ν_2 at 299 K and 3 = ν_3 at 291 K.

footnote for Tables 4 and 5

$^+$ The H_2-broadened widths are in units of cm^{-1}/atm at the given temperature.

Table 1 EXPERIMENTAL CONDITIONS

Bandpass:	600-2700 cm^{-1}	1800-5200 cm^{-1}	0.0-350 cm^{-1}
Instrument:	Kitt Peak FTS	Kitt Peak FTS	Bruker FTS at JPL
Resolution:	0.0056 cm^{-1}	0.012 cm^{-1}	0.0056 cm^{-1}
Integration:	1 hour	1 hour	9-14 hours
Detectors:	As-Si (He-cooled)	InSb	bolometer (He-cooled)
Paths:	1.5 m	1.5 m	0.26 m
Pressures (in Torr):			
	H_2 H_2O	H_2 H_2O	H_2 H_2O
	355 0.51 at 299K	390 0.81 at 292K	85 0.35 at 297K
	400 0.20 at 300K	400 2.22 at 290K	147 0.09 at 294K
	447 0.52 at 299K	466 0.50 at 292K	388 0.10 at 294K
	513 0.37 at 299K	500 2.29 at 290K	584 0.25 at 298K
	558 0.77 at 299K	512 1.05 at 291K	748 0.18 at 294K
	764 2.12 at 300K		938 0.17 at 295K
	993 2.20 at 300K		

Table 2 DISTRIBUTION OF THE MEASURED H_2- BROADENED H_2O WIDTHS

Band	cm^{-1}	#Widths	Region cm^{-1}	Maximum J.Ka	Sample Temperatures
Rot.	0.	64	55 - 328	9,6	295 ± 2 K
ν_2	1595.	273	1260 - 2041	12,6	299 ± 1 K
ν_1	3657.	103	3420 - 3975	10,5	291 ± 1 K
ν_3	3756.	190	3480 - 4045	11,5	291 ± 1 K
		total 630			

+ ν_2 widths obtained from more than 7 spectra are at an effective temperature of ≈ 295 K.

Table 3 Observed H_2-Broadened Widths of $H_2{}^{16}O$ in Four Bands*

Position	It-item	%unc	width	%unc	vib	J'	Ka'	Kc'	J"	Ka"	Kc"	sc/so	#
1557.6092	1.45+0	(0.6)	0.0880	(1.0)	2	0	0	0	1	1	1	0.97	5
3619.91464	.90-2	(2.4)	0.0893	(5.6)	1	0	0	0	1	1	1	1.01	5
3779.4914	1.08+0	(1.4)	0.0907	(0.8)	3	1	0	1	0	0	0	0.97	5
1576.1855	6.43+0	(1.2)	0.0888	(1.4)	2	1	0	1	1	1	0	0.99	5
3638.0806	1.95-1	(0.9)	0.0918	(0.9)	1	1	0	1	1	1	0	o.%	5
3709.4016	1.65+0	(0.9)	0.0865	(0.7)	3	1	0	1	2	0	2	0.98	5
3600.%65	2.18-1	(1.4)	0.0901	(1.0)	1	1	0	1	2	1	2	0.95	5
1616.7115	5.82+0	(1.1)	0.0892	(1.2)	2	1	1	0	1	0	1	0.98	5
3759.8435	1.37+0	(1.2)	0.0966	(0.8)	3	1	1	0	1	1	1	0.98	5
3701.8044	1.12+0	(3.1)	0.0916	(0.7)	3	1	1	0	2	1	1	0.98	5
1505.6043	4.70+0	(0.8)	0.0825	(1.0)	2	1	1	0	2	2	1	0.98	5
3563.5887	1.91-1	(0.9)	0.0880	(1.1)	1	1	1	0	2	2	1	0.95	5
1634.9671	1.50+0	(0.2)	0.0900	(0.5)	2	1	1	1	0	0	0	0.96	5
3693.29244	.04-2	(2.0)	0.0963	(2.3)	1	1	1	1	0	0	0	0.94	4
1564.87638.20-1		(0.2)	0.0887	(0.6)	2	1	1	1	2	0	2	0.97	7
3712.2047	3.49+0	(2.7)	0.0953	(2.9)	3	1	1	1	2	1	2	0.99	5
1627.8275	1.05+0	(0.5)	0.0882	(0.6)	2	2	0	2	1	1	1	0.96	7
1569.7887	2.46+0	(0.6)	0.0878	(0.7)	2	2	0	2	2	1	1	0.98	7
1522.6861	1.79+0	(0.3)	0.0769	(0.2)	2	2	0	2	3	1	3	0.96	5
3807.0124	3.65+0	(2.8)	0.0923	(2.7)	3	2	1	1	1	1	0	1.01	5
1623.5592	2.10+0	(0.6)	0.0878	(0.s)	2	2	1	1	2	0	2	0.97	7
3680.37256.36-2		(0.7)	0.0927	(2.4)	1	2	1	1	2	0	2	0.96	5
3769.8884	1.83+0	(1.3)	0.0957	(1.1)	3	2	. 1	1	2	1	2	0.98	5
1557.4861	1.30+0	(0.7)	0.0824	(1.0)	2	2	1	1	2	2	0	0.97	5
3614.2995	3.63-2	(3.7)	0.0906	(3.3)	1	2	1	1	2	2	0	0.95	5
1487.3485	1.22+0	(0.2)	0.0802	(0.3)	2	2	1	1	3	2	2	0.96	5
3544.16175.72-2		(1.5)	0.0861	(2.0)	1	2	1	1	3	2	2	0.98	5
3563.9656	2.48-2	(4.0)	0.0861	(0.5)	3	2	1	1	3	3	0	0.93	4
55.7021	1.10+1	(2.3)	0.0854	(0.8)	O	2	1	2	1	0	1	0.98	6
1653.2671	6.14+0	(1.7)	0.0928	(3.4)	2	2	1	2	1	0	1	0.96	5
3711.1015	1.43-1	(1.2)	0.0905	(0.8)	1	2	1	2	1	0	1	0.94	5
3796.4384	1.30+0	(1.2)	0.0925	(0.8)	3	2	1	2	1	1	1	0.98	5
3738.3w4	6.15-1	(1.2)	0.0943	(0.8)	3	2	1	2	2	1	1	0.97	5
1542.1598	2.74+0	(0.4)	0.0878	(0.8)	2	2	1	2	2	2	1	0.99	5
1540.2998	4.06+0	(0.5)	0.0767	(1.3)	2	2	1	2	3	0	3	0.98	5
3598.1346	1.87-1	(0.9)	0.0832	(0.4)	1	2	1	2	3	0	3	0.95	5
3691.2967	1.60+0	(1.2)	0.0820	(1.8)	3	2	1	2	3	1	3	0.97	5
1464.9051	2.18+0	(0.2)	0.0874	(0.3)	2	2	1	2	3	2	1	0.97	5
3863.3195	1.09-1	(1.1)	0.1009	(1.9)	3	2	2	0	1	0	1	0.98	5
1648.3105	9.79-1	(0.2),	0.0840	(0.1)	2	2	2	0	2	1	1	0.96	5
3694.7925	2.43-2	(1.8)	0.0821	(1.5)	1	2	2	0	2	1	1	0.99	3
1458.2670	1.38+0	(0.9)	0.0618	(0.3)	2	2	2	0	3	3	1	1.01	5
3504.7486	6.24-2	(1.6)	0.0675	(0.6)	1	2	2	0	3	3	1	0.99	5
92.5301	2.52+1	(5.5)	0.0847	(3.7)	o	2	2	1	1	1	0	1.00	6
1699.9339	4.45+0	(0.6)	0.0830	(0.8)	2	2	2	1	1	1	0	0.97	5
3746.3215	1.15-1	(1.4)	0.0894	(0.8)	1	2	2	1	1	1	0	0.93	3
55.4053	4.52+0	(3.2)	0.0859	(1.7)	o	2	2	1	2	1	2	1.00	6
3749.5725	1.79+0	(3.0)	0.0836	(4.3)	3	2	2	1	2	2	0	1.02	3
1568.9399	5.29-1	(0.3)	0.0828	(1.0)	2	2	2	1	3	1	2	0.98	7
3679.4355	7.42-1	(1.0)	0.0793	(0.7)	3	2	2	1	3	2	2	0.97	5
1456.8871	4.06+0	(0.9)	0.0646	(1.4)	2	2	2	1	3	3	0	1.02	5
3503.274S	1.88-1	(0.5)	0.0684	(1.0)	1	2	2	1	3	3	0	0.97	5
3820.7375	2.05+0	(2.0)	0.0819	(2.3)	3	3	0	3	2	0	2	0.99	5
57.2651	1.03+1	(2.8)	0.0789	(1.1)	O	3	0	3	2	1	2	0.97	6
1652.4003	5.31+0	(3.6)	0.0755	(2.7)	2	3	0	3	2	1	2	1.06	5
3711.8746	1.06-1	(1.1)	0.0846	(1.2)	1	3	0	3	2	1	2	0.94	5
1558.5309	5.73+0	(1.1)	0.0849	(1.9)	2	3	0	3	3	1	2	1.00	5
3618.0057	1.68-1	(1.5)	0.0922	(0.7)	1	3	0	3	3	1	2	0.93	5
3684.52669.34-2		(1.1)	0.0862	(0.7)	3	3	0	3	3	2	2	0.98	5
3668.7756	1.61+0	(1.5)	0.0739	(1.6)	3	3	0	3	4	0	4	0.97	5
1507.0583	4.72+0	(1.1)	0.0691	(1.4)	2	3	0	3	4	1	4	0.98	5
3566.5326	2.64-1	(0.9)	0.0730	(0.9)	1	3	0	3	4	1	4	0.95	5
3575.04863.36-2		(3.0)	0.0'214	(4.7)	3	3	0	3	4 2		2	0.95	5
3831.6854	1.64+0	(1.3)	0.0871	(1.1)	3	3	1	2	2	1	1	0.98	5
1637.51198	.17-1	(0.5)	0.0824	(0.5)	2	3	1	2	2	2	1	0.97	7
163S.6519	4.48+0	(0.6)	0.0.835	(0.6)	2	3	1	2	3	0	3	0.98	5

3690.6306	1.44-1	(2.1)	0.0897	(2.8)	1	3	1	2	3	0	3	0.92	5
3784.5825	3.19-1	(1.1)	0.0883	(1.0)	3	3	1	2	3	1	3	o.%	5
1560.2572	5.30+0	(0.8)	0.0806	(1.1)	2	3	1	2	3	2	1	1.01	5
3615.23%	1.48-1	(0.6)	0.0832	(1.1)	1	3	1	2	3	2	1	0.98	5
3641.6417	9.35-3	(4.8)	0.0900	(5.7)	3	3	1	2	3	3	1	0.95	4
3651.3635	1.23+0	(2.4)	0.0847	(2.2)	3	3	1	2	4	1	3	0.99	3
1472.0512	2.62+0	(0.4)	0.0752	(0.7)	2	3	1	2	4	2	3	0.97	5
72.1880	6.80+0	(2.0)	0.0785	(1.8)	O	3	1	3	2	0	2	0.98	6
1669.3929	2.41+0	(0.7)	0.0783	(0.6)	2	3	1	3	2	0	2	o.%	7
3726.44754.03-2		(3.3)	0.0828	(0.4)	1	3	1	3	2	0	2	1.08	3
3816.0914	5.18+0	(4.2)	0.0845	(4.2)	3	3	1	3	2	1	2	1.03	5
3722.22149	.63-1	(1.0)	0.0887	(0.4)	3	3	1	3	3	1	2	0.97	5
1s33.1823	1.07+0	(0.3)	.0.0776	(0.1)	2	3	1	3	3	2	2	0.98	5
1517.4310	1.47+0	(0.3)	0.0651	(1.0)	2	3	1	3	4	0	4	0.97	5
3574.48567.68-2		(2.1)	0.0705	(4.4)	1	3	1	3	4	0	4	0.95	5
1423.70423.14-1		(0.5)	0.0808	(0.9)	2	3	1	3	4	2	2	0.97	7
3892.8254	7.28-2	(1.3)	0.0944	(1.9)	3	3	2	1	2	0	2	0.97	5
132.6604	2.48+1	(5.2)	0.0899	(3.6)	O	3	2	1	2	1	2	0.97	6
1739.8388	2.28+0	(0.2)	0.0869	(0.3)	2	3	2	1	2	1	2	o.%	5
3785.26669	.04-2	(1.6)	0.0920	(2.8)	1	3	2	1	2	1	2	0.93	5
3826.7524	8.29-1	(1.0)	0.0795	(0.9)	3	3	2	1	2	2	0	0.98	5
1645.9693	4.00+0	(0.5)	0.0803	(0.8)	2	3	2	1	3	1	2	0.99	5
3691.39649	.46-2	(2.2)	0.0794	(3.1)	1	3	2	1	3	1	2	1.00	5
37S6.6154	8.63-1	(1.1)	0.0793	(0.9)	3	3	2	1	3	2	2	0.98	5
1533.9165	1.85+0	(0.2)	0.0691	(0.3)	2	3	2	1	3	3	0	1.01	5
3579.34364.92-2		(0.6)	0.0751	(1.1)	1	3	2	1	3	3	0	0.97	5
1594.4968	1.68-1	(0.9)	0.0793	(2.2)	2	3	2	1	4	1	4	1.01	7
3647.13758	.47-1	(1.2)	0.0793	(0.9)	3	3	2	1	4	2	2	0.97	3
1436.8182	2.48+0	(1.7)	0.0675	(2.5)	2	3	2	1	4	3	2	1.02	7
3482.2457	1.38-1	(1.2)	0.0728	(1.6)	1	3	2	1	4	3	2	0.97	5
.111.1262	1.03+1	(4.1)	0.0829	(1.8)	O	3	2	2	2	1	1	0.96	6
1718.6117	1.32+0	(0.2)	0.0821	(0.1)	2	3	2	2	2	1	1	0.95	5
3763.6985	3.04-2	(1.2)	0.0844	(1.9)	1	3	2	2	2	1	1	0.94	4
3821.7623	2.42+0	(2.7)	0.0814	(2.9)	3	3	2	2	2	2	1	1.01	5
3819.9035	2.62-1	(1.1)	0.0864	(1.6)	3	3	2	2	3	0	3	0.97	5
64.0234	2.43+0	(5.2)	0.0766	(1.5)	o	3	2	2	3	1	3	0.93	4
1671.5091	7.05-1	(4.0)	0.0765	(1.1)	2	3	2	2	3	1	3	1.01	5
3744.5085	2.80+0	(0.5)	0.0750	(1.3)	3	3	2	2	3	2	1	0.91	3
1528.5682	5.%-1	(0.3)	0.0678	(0.3)	2	3	2	2	3	3	1	1.01	7
3573.6546	1.59-2	(1.6)	0.0720	(1.8)	1	3	2	2	3	3	1	o.%	3
3656.3025	2.56+0	(3.1)	0.0742	(3.2)	3	3	2	?	4	2	3	0.98	5
1429.9451	7.98-1	(0.3)	0.0649	(0.7)	2	3	2	2	4	3	1	1.00	7
3475.03164.46-2		(2.2)	0.0.737	(2.4)	1	3	2	2	4	3	1	0.94	5
150.5182	5.96+1	(2.4)	0.0663	(3.7)	o	3	3	0	2	2	1	0.99	5
1772.7142	3.53+0	(0.5)	0.0641	(0.4)	2	3	3	0	2	2	1	0.98	5
3800.4416	1.56-1	(1.1)	0.0705	(3.4)	1	3	3	0	2	2	1	0.93.	5
73.26315.28+0		(3.9)	0.0701	(3.5)	o	3	3	0	3	2	1	1.00	6
16%.4594	1.16+0	(0.2)	0.0703.	(0.5)	2	3	3	0	3	2	1	0.98	5
3745.0854	1.39+0	(1.9)	0.0602	(2.2)	3	3	3	0	3	3	1	0.99	5
1607.25359.95-2		(1.3)	0.0689	(2.6)	2	3	3	0	4	2	3	1.03	7
3646.46263	.42-1	(0.7)	0.0642	(0.3)	3	3	3	0	4	3	1	0.96	3
1419.5080	2.35+0	(3.1)	0.0489	(3.1)	2	3	3	0	4	4	1	1.08	7
3447.2366	1.31-1	(1.5)	0.0509	(4.1)	1	3	3	0	4	4	1	0.96	5
149.0566	1.99+1	(7.4)	0.0668	(5.4)	o	3	3	1	2	2	0	0.98	6
1771.2875	1.20+0	(0.3)	0.0628	(0.7)	2	3	3	1	2	2	0	0.97	5
1701.15003.70-1		(0.4)	0.0687	(1.0)	2	3	3	1	3	2	2	0.98	5
3647.5516	1.01+0	(1.0)	0.0636	(0.9)	3	3	3	1	4	3	2	0.97	3
1419.3172	8.13-1	(0.6)	0.0482	(2.0)	2	3	3	1	4	4	0	1.03	7
3447.07554.43-2		(5.1)	0.0542	(4.6)	1	3	3	1	4	4	0	0.93	5
3837.8686	5.42+0	(5.8)	0.0773	(5.4)	3	4	0	4	3	0	3	1.05	4
1675.1728	2.32+0	(0.3)	0.0662	(0.4)	2	4	0	4	3	1	3	0.97	5
3762.47364.62-2		(3.5)	0.0893	(5.0)	3	4	0	4	3	2	1	0.96	5
1541.9542	1.23+0	(0.1)	0.0747	(0.6)	2	4	0	4	4	1	3	0.99	5
3599.5186	3.40-2	(3.7)	0.0832	(5.5)	1	4	0	4	4	1	3	0.94	5
1490.8257	1.25+0	(0.4)	0.0570	(0.3)	2	4	0	4	5	1	5	0.97	7
3548.39078.01-2		(1.6)	0.0648	(1.7)	1	4	0	4	5	1	5	0.91	5
3528.11974	.55-2	(1.3)	0.0836	(1.9)	3	4	0	4	5	2	3	0.96	5
1669.1683	5.02-1	(3.0)	0.0731	(4.1)	2	4	1	3	3	2	2	0.97	7
1653.4170	7.40-1	(4.3)	0.0651	(2.1)	2	4	1	3	4	0	4	1.13	4
3705.7485	2.64-2	(2.7)	0.0807	(4.3)	1	4	1	3	4	0	4	0.95	5
3802.96465.13-1		(1.1)	0.0798	(1.1)	3	4	1	3	4	1	4	0.96	5
1559.6901	1.62+0	(0.5)	0.0762	(0.8)	2	4	1	3	4	2	2	0.99	5

3612.02144	.45-2	(1.7)	0.0824	(4.3)	1	4	1	3	4	2	2	0.95	5
3645.2866	6.62-2	(0.9)	0.0797	(2.2)	3	4	1	3	4	3	2	0.98	5
3628.3454	2.58+0	(6.0)	0.0786	(4.5)	3	4	1	3	5	1	4	1.00	5
1459.26105.90-1		(0.4)	0.0677	(0.6)	2	4	1	3	5	2	4	0.97	3
3511.59263.76-2		(1.2)	0.0748	(4.5)	1	4	1	3	5	2	4	0.97	5
3518.9905	5.02-2	(3.1)	0.0813	(5.1)	3	4	1	3	5	3	2	0.95	5
1684.8352	7.22+0	(1.9)	0.0707	(2.2)	2	4	1	4	3	0	3	1.00	5
3834.9814	1.7440	(1.9)	0.0701	(2.0)	3	4	1	4	3	1	3	0.99	s
1609.4405	2.71-1	(1.0)	0.0805	(0.6)	2	4	1	4	3	2	1	0.99	7
1521.2345	2.58+0	(3.2)	0.0625	(0.5)	2	4	1	4	4	2	3	1.01	5
3577.2115	7.21-2	(1.2)	0.0732	(0.8)	1	4	1	4	4	2	3	0.97	5
1496.2489	3.59+0	(0.7)	0.0561	(0.9)	2	4	1	4	5	0	5	0.99	5
3552.22662	.17-1	(0.7)	0.0602	(1.8)	1	4	1	4	5	0	5	0.95	s
1375.0861	3.49-1	(0.6)	0.0758	(1.2)	2	4	1	4	5	‘2	3	0.99	7
3929.3595	1.88-1	(1.5)	0.0889	(1.2)	3	4	2	2	3	0	3	1.00	5
173.5023	6.45+0	(3.4)	0.0817	(1.1)	o	4	2	2	3	1	3	0.95	6
3824.27959	.47-2	(1.2)	0.0870	(1.6)	1	4	2	2	3	1	3	0.95	5
1637.68188	.24-2	(4.7)	0.0731	(3.9)	2	4	2	2	3	3	1	0.95	7
1647.4041	1.18+0	(0.2)	0.0753	(0.7)	2	4	2	2	4	1	3	0.99	5
3765.7585	1.15+0	(1.2)	0.0770	(1.0)	3	4	2	2	4	2	3	0.97	5
3582.71562.11-2		(4.2)	0.0729	(4.9)	1	4	2	2	4	3	1	1.01	5
3639.93272.92-2		(2.0)	0.0854	(5.0)	1	4	2	2	5	1	5	0.95	5
3619.6106	1.97+0	(2.8)	0.0780	(2.1)	3	4	2	2	5	2	3	0.98	5
1418.93304.61-1		(0.4)	0.0650	(1.4)	2	4	2	2	5	3	3	0.99	7
3462.58973	.25-2	(3.2)	0.0746	(3.9)	1	4	2	2	5	3	3	0.95	5
126.99803.0%1		(6.8)	0.0803	(5.6)	O	4	2	3	3	1	2	0.98	6
1734.6506	3.27+0	(0.3)	0.0771	(0.3)	2	4	2	3	3	1	2	0.97	5
3777.94856	.40-2	(1.4)	0.0808(1.2)		1	4	2	3	3	1	2	0 . 9 4	5
3843.74%	9.95-1	(1.3)	0.0728	(1.1)	3	4	2	3	3	2	2	0 . 9 8	5
1622.59782.02-1		(0.8)	0.0689(1.7)		2	4	2	3	3	3	0	1.00	7
3827.9985	9.25-2	(2.0)	0.0761	(1.9)	3	4	2	3	4	0	4	0.96	5
75.5247	7.47+0	(1 .9)	0.0666	(0.6)	O	4	2	3	4	1	4	0.99	6
1683.1780	1.68+0	(0.3)	0.0662	(0.9)	2	4	2	3	4	1	4	0.98	5
1525.4995	2.02+0	(0.7)	0.0631	(1.0)	2	4	2	3	4	3	2	1.02	7
3568.79765.45-2		(1.8)	0.0693	(2.9)	1	4	2	3	4	3	2	0.97	5
1508.5588	1.02+0	(0.6)	0.0664	(0.9)	2	4	2	3	5	1	4	0.99	5
3551.8565	5.18-2	(3.5)	0.0743	(4.8)	1	4	2	3	5	1	4	0.93	5
3633.84257	.06-1	(0.9)	0.0647	(0.6)	3	4	2	3	5	2	4	0.96	5
1399.2042	1.15+0	(0.5)	0.0640	(0.5)	2	4	2	3	5	3	2	1.00	7
3442.50167.34-2		(0.9)	0.0690	(1.7)	1	4	2	3	5	3	2	0.97	5
3953.0964	7.27-2(1.5)		0.0826	(2.3)	3	4	3	1	3	1	2	1.01	5
1799.61577.70-1		(0.3)	0.0654	(1.0)	2	4	3	1	3	2	2	0.97	7
3825.5505	7.34-2	(0.9)	0.0728	(3.2)	1	4	3	1	3	2	2	0.94	5
3841.0434	1.11+0	(1.3)	0.0628	(1.6)	3	4	3	1	3	3	0	0.99	5
68.0647	1.90+0	(1.3)	0.0696	(1.9)	O	4	3	1	4	2	2	o.%	4
1690.137S	4.63-1	(0.2)	0.0692	(0.9)	2	4	3	1	4	2	2	0.99	6
3743.9455	1.45+0	(2.8)	0.0622	(2.5)	3	4	3	1	4	3	2	0.99	4
3617.64958,21-1		(1.1)	0.0664	(0.7)	3	4	3	1	5	3	2	0.97	5
1395.8026'	4.36-1	(0.4)	0.0527(1.4)		2	4	3	1	5	4	2	1.04	7
3982.8685	1.02-2	(2.1)	0.0831	(2.9)	3	4	3	2	3	1	3	1.02	3
170.3631	4.95+1	(1.6)	0.0700	(2.6)	O	4	3	2	3	2	1	0.98	5
1792.6594	2.42+0	(0.1)	0.0682	(0.1)	2	4	3	2	3	2	1	0.98	5
3818.68159.08-2		(0.9)	0.0725	(1.1)	1	4	3	2	3	2	1	0.93	5
3839.9284	3.87-1	(1.4)	0.0626	(1.5)	3	4	3	2	3	3	1	0.99	5
82.1564	7.24+0	(2.8)	0.0640	(1.5)	o	4	3	2	4	2	3	0.98	6
1704.4534	1.23+0	(0.1)	0.0632	(0.8)	2	4	3	2	4	2	3	0.99	5
3741.3044	5.26-1	(1.2)	0.0632	(0.4)	3	4	3	2	4	3	1	0.98	5
1516.70797	.57-1	(0.6)	0.0550	(1.1)	2	4	3	2	4	4	1	1.03	5
3621.17952.92-1		(0.7)	0.0623	(1.3)	3	4	3	2	5	3	3	0.97	5
1394.4745	1.31+0	(3.3)	0.0532	(1.3)	2	4	3	2	5	4	1	1.03	7
3420.49668.05-2		(0.4)	0.0577	(0.9)	1	4	3	2	5	4	1	0.98	3
4012.6935	1.33-2	(2.6)	0.0715	(4.0)	3	4	4	0	3	2	1	1.08	3
202.9188	2.27+1	(0.9)	0.0500	(2.4)	O	4	4	0	3	3	1	0.98	5
1844.3993	6.36-1	(0.3)	0.0485	(0.7)	2	4	4	0	3	3	1	1.04	5
104.2939	1.51+0	(4.6)	0.0556	(2.9)	O	4	4	0	4	3	1	0.95	6
1745.7762	1.32-1	(0.6)	0.0576	(1.5)	2	4	4	0	4	3	1	1.00	7
3750.9546	1.46-1	(1.2)	0.0636	(1.4)	1	4	4	0	4	3	1	0.94	4
3630.82976.53-2		(7.4)	0.0670	(2.7)	1	4	4	0	5	3	3	0.95	4
3614.50863	.48-1	(1.1)	0.0538	(0.3)	3	4	4	0	5	4	1	0.97	5
1387.S456	3.41-1	(5.2)	0.0420	(0.8)	2	4	4	0	5	5	1	1.03	3
202.6931	6.59+1	(3.1)	0.0517	(5.3)	o	4	4	1	3	3	0	1.00	s
1844.1806	1.90+0	(0.3)	0.0492	(0.6)	2	4	4	1	3	3	0	1.05	5

105.5930	4.52+0	(4.0)	0.0562	(2.4)	O	4	4	1	4	3	2	0.98	6
1747.08233.94-1		(1.1)	0.0565	(1.9)	2	4	4	1	4	3	2	1.00	7
3752.4995	5.30-1	(1.9)	0.0587	(0.7)	1	4	4	1	4	3	2	0.97	3
3626.20462	.53-1	(1.0)	0.0666	(0.8)	1	4	4	1	5	3	2	0.94	5
3614.7005	1.16-1	(0.9)	0.0534	(2.5)	3	4	4	1	5	4	2	0.97	5
1387.52299	.35-1	(5.0)	0.0410	(0.5)	2	4	4	1	5	5	0	1.13	5
1695.9282	6.28+0	(2.0)	0.0582	(2.0)	2	5	0	5	4	1	4	1.01	5
3751.46858	.10-2	(1.3)	0.0654	(3.8)	1	5	0	5	4	1	4	0.91	3
1521.3090	2.14+0	(1.7)	0.0627	(1.0)	2	5	0	5	5	1	4	0.98	5
3576.'8497	50-2	(2.0)	0.0710	(4.3)	1	5	0	5	5	1	4	0.98	5
3659.93366	.92-2	(0.6)	0.0650	(2.3)	3	5	0	5	5	2	4	0.97	5
3629.44468	.55-1	(1.3)	0.0535	(1.0)	3	5	0	5	6	0	6	0.95	5
1473.5142	2.51+0	(0.4)	0.0492	(0.6)	2	5	0	5	6	1	6	0.99	5
3529.0545	1.75-1	(0.9)	0.0526	(0.8)	1	5	0	5	6	'1	6	0.95	5
1271.78784.51-2		(3.5)	0.0631	(3.2)	2	5	0	5	6	3	4	1.02	7
3874.4006	1.12+0	(1.3)	0.0752	(1.2)	3	5	1	4	4	1	3	0.98	5
1700.5008	1.75+0	(0.2)	0.0677	(0.4)	2	5	1	4	4	2	3	0.99	5
74.1100	5.46+0	(3.8)	0.0665	(2.4)	O	5	1	4	5	0	5	0.98	6
1675.5152	1.29+0	(0.1)	0.0652	(0.5)	2	5	1	4	5	0	5	0.98	5
3724.1875	3.72-2	(0.8)	0.0686	(3.8)	1	5	1	4	5	0	5	0.99	5
3823.2724	9.18-2	(0.5)	0.0718	(2.6)	3	5	1	4	5	1	5	0.96	5
1554.3524	3.14+0	(0.4)	0.0721	(0.7)	2	5	1	4	5	2	3	1.00	5
3603.0245	8.21-2	(1.9)	0.0767	(1.8)	1	5	1	4	5	2	3	0.97	5
3645.92942.82-2		(3.0)	0.0673	(1.0)	3	5	1	4	5	3	3	1.02	3
3606.9924	5.50-1	(1.2)	0.0677	(0.6)	3	5	1	4	6	1	5	0.95	5
1447.9516	1.08+0	(0.4)	0.0611	(0.3)	2	5	1	4	6	2	5	0.98	7
3496.62368.04-2		(1.1)	0.0680	(2.6)	1	5	1	4	6	2	5	0.95	5
104.5738	1.17+1	(5.3)	0.0590	(4.7)	o	5	1	5	4	0	4	0.98	6
1700.7763	2.23+0	(0.6)	0.0569	(0.7)	2	5	1	5	4	0	4	0.98	5
3755.40262.79-2		(2.0)	0.0660	(5.9)	1	5	1	5	4	0	4	0.92	3
1607.0495	4.05-2	(4.5)	0.0739	(5.5)	2	5	1	5	4	2	2	1.05	5
3677.4375	2.25-1	(0.8)	0.0716	(0.2)	3	5	1	5	5	1	4	0.97	3
1506.6203	5.92-1	(0.2)	0.0588	(0.4)	2	5	1	5	5	2	4	0.99	5
1476.1325	8.36-1	(0.4)	0.0471	(0.2)	2	5	1	5	6	0	6	0.98	7
3530.7585	5.73-2	(1.6)	0.0505	(3.2)	1	5	1	5	6	0	6	0.94	5
3629.64262.43+0		(4.3)	0.0537	(4.3)	3	5	1	5	6	1	6	0.98	5
3973.91733.37-2		(2.5)	0.0799	(5.1)	3	5	2	3	4	0	4	1.02	4
221.6745	1.18+1	(2.6)	0.0771	(1.5)	o	5	2	3	4	1	4	0.98	6
1829.12974.11-1		(1.8)	0.0780	(1.5)	2	5	2	3	4	1	4	1.03	5
3871.0804	4.63-2	(4.9)	0.0825	(5.3)	1	5	2	3	4	1	4	0.94	5
3880.19038	.29-1	(4.7)	0.0795	(0.9)	3	5	2	3	4	2	2	0.99	5
1671.45193	.87-1	(5.6)	0.0680	(2.2)	2	5	2	3	4	3	2	0.95	4
1654.5112	2.17+0	(0.2)	0.0717	(0.4)	2	5	2	3	5	1	4	0.99	5
36%.4615	1.05-1	(1.2)	0.0762	(2.4)	1	5	2	3	5	1	4	0.97	5
3779.7605	1.63-1	(0.9)	0.0741	(1.0)	3	5	2	3	5	2	4	0.97	5
1545.1566	1.93+0	(0.2)	0.0672	(0.3)	2	5	2	3	5	3	2	1.01	5
3648.66665.10-2		(1.7)	0.0782	(1.9)	1	5	2	3	6	1	6	0.91	4
3593.1956	4.18-1	(1.3)	0.0753	(0.5)	3	5	2	3	6	2	4	0.95	5
1404.9900,6	.85-1	(0.4)	0.0633	(0.6)	2	5	2	3	6	3	4	1.01	7
140.7139	9.32+0	(4.4)	0.0698	(3.2)	O	5	2	4	4	1	3	0.98	6
1748.65578	.64-1	(0.4)	0.0697	(0.7)	2	5	2	4	4	1	3	0.97	6
3865.1106	2.17+0	(2.9)	0.0677	(3.4)	3	5	2	4	4	2	3	1.02	5
1640.31028.38-2		(2.2)	0.0645	(3.7)	2	5	2	4	4	3	1	1.00	7
3840.1255	1.88-1	(1.0)	0.0669	(1.6)	3	5	2	4	5	0	5	0.96	5
89.5845	2.27+0	(4.9)	0.0572	(3.2)	O	5	2	4	5	1	5	0.98	5
1697.52723.48-1		(0.4)	0.0572	(0.7)	2	5	2	4	5	1	5	0.98	7
3718.96265.18-1		(1.2)	0.0731	(0.8)	3	5	2	4	5	2	3	0.97	5
1520.1845	5.75-1	(4.4)	0.0586	(3.0)	2	5	2	4	5	3	3	0.94	3
1481.2469	2.84-1	(0.5)	0.0578	(1.0)	2	5	2	4	6	1	5	0.99	7
3612.5615	1.29+0	(2.0)	0.0593	(1.3)	3	5	2	4	6	2	5	0.%	5
1362.6037	1.47-1	(1.1)	0.0620	(2.1)	2	5	2	4	6	3	3	1.02	7
3972.6534	2.41-2	(1.4)	0.0756	(2.6)	3	5	3	2	4	1	3	1.01	4
1830.1321	1.24+0	(0.3)	0.0637	(0.9)	2	5	3	2	4	2	3	1.04	7
3853.5744	4.66-1	(1.4)	0.0666	(2.9)	1	5	3	2	4	2	3	0.99	5
3864.3085	2.73-1	(1.0)	0.0635	(1.4)	3	5	3	2	4	3	1	0.98	5
1642.38667.14-2		(3.0)	0.0608	(3.9)	2	5	3	2	4	4	1	1.03	7
62.3039	4.05+0	(2.3)	0.0689	(1.2)	o	5	3	2	5	2	3	0.95	6
1683.9837	1.17+0	(0.2)	0.0676	(1.6)	2	5	3	2	5	2	3	1.00	5
1520.1531	7.79-1	(5. o)	0.0564	(1.3)	2	5	3	2	5	4	1	1.06	4
1577.5829	7.32-2	(4.6)	0.0580	(5.7)	2	5	3	2	6	2	5	1.10	6
3601.0257	1.40-1	(1.7)	0.[)650	(1.5)	1	5	3	2	6	2	5	0.96	5
1373.7695	6.18-1	(0.3)	0.0552	(0.6)	2	5	3	2	6	4	3	1.04	7

281.9203	1.54+0	(1.1)	0.0785	(4.8)	O	5	3	3	4	0	4	0.90	3
4019.4654	2.70-2	(1.6)	0.0767	(2.7)	3	5	3	3	4	1	4	1.02	4
188.1925	1.18+1	(4.3)	0.0693	(1.9)	o	5	3	3	4	2	2	0.98	6
1810.6282	4.99-1	(2.6)	0.0685	(1.2)	2	5	3	3	4 .	2	2	0.99	11
3861.7865	1.13+0	(2.1)	0.0612	(1.8)	3	5	3	3	4	3	2	0.99	5
3844.8454	5.30-2	(4.2)	0.0714	(5.2)	3	5	3	3	5	1	4	0.99	5
87.7621	2.06+0	(4.4)	0.0567	(2.0)	O	5	3	3	5	?	4	0.99	6
1710.19903	.05-1	(0.7)	0.0577	(1.3)	2	5	3	3	“ 5	2	4	0.99	7
1516.29332	.61-1	(1.2)	0.0520	(1.0)	2	5	3	3	. 5	4	2	1.05	5
1523.63436	.01-2	(5.7)	0.0656	(5.6)	2	5	3	3	6	2	4	0.98	5
3595.3245	5.57-1	(1.4)	0.05%	(0.7)	3	5	3	3	6	3	4	o.%	5
1368.6275	2.02-1	(0.5)	0.0522	(1.4)	2	5	3	3	6	4	2	1.05	7
1869.3457	1.13+0	(0.4)	0.0548	(0.5)	2	5	4	1	4	3	2	1.05	12
3873.72352	.39-1	(1.4)	0.0588	(2.2)	1	5	4	1	4 '	3	2	0.99	5
3857.4234	1.49-1	(1.5)	0.0550	(1.7)	3	5	4	1	4	4	0	0.99	5
3856.7824	1.95-2	(6.5)	0.0765	(3.8)	1	5	4	1	5	1	4	0.97	5
101.5329	4.37+0	(4.4)	0.0575	(2.5)	O	5	4	1	5	3	2	0.97	5
3747.42753	.03-1	(1.5)	0.0634	(0.9)	1	5	4	1	5	3	2	0.95	5
3607.2614	2.19-1	(1.1)	0.0603	(1.3)	1	5	4	1	6	3	4	0.94	5
3587.7777	1.08-1	(1.7)	0.0565	(0.6)	3	5	4	1	6	4	2	0.96	5
1363.26384	.72-1	(0.6)	0.0472	(0.9)	2	5	4	1	6	5	2	1.08	7
1867.85293.80-1		(0.6)	0.0555	(1.6)	2	5	4	2	4	3	1	1.04	12
3873.9425	1.83-1	(2.5)	0.0640	(2.7)	1	5	4	2	4	3	1	0.98	5
3857.16344.47-1		(1.6)	0.0534	(1.2)	3	5	4	2	4	4	1	0.99	5
106.1501	1.58+0	(2.7)	0.0539	(1.5)	o	5	4	2	5	3	3	0.97	6
1747.7272	1.33-1	(1.9)	0.0540	(3.2)	2	5	4	2	5	3	3	1.02	7
3753.8176	1.70-1	(0.8)	0.0617	(0.2)	1	5	4	2	5	3	3	0.97	3
1509.62238.52-2		(5.1)	0.0479	(2.4)	2	5	4	2	5	5	1	0.99	5
3596.2366	1.36-1	(2.3)	0.0690	(2.0)	1	5	4	2	6	3	3	0.95	5
3588.54573	.21-1	(1.5)	0.0542	(0.7)	3	5	4	2	6	4	3	o.%	5
1363.06271.57-1		(2.2)	0.0470	(2.7)	2	5	4	2	6	5	1	1.08	7
1918.03546	.81-1	(4.1)	0.0440	(1.8)	2	5	5	0	4	4	1	1.09	6
131.7390	2.36+0	(3.1)	0.0491	(2.7)	O	5	5	0	5	4	1	0.94	5
1795.8019	1.06-1	(2.9)	0.0519	(2.5)	2	5	5	0	5	4	1	1.01	7
3771.56153	.88-2	(1.9)	0.0532	(2.2)	1	5	5	0	5	4	1	0.94	5
3580.06452	.93-2	(5.5)	0.0463	(1.1)	3	5	5	0	6	5	1	1.01	3
1918.00682	.24-1	(4.7)	0.0442	(1.2)	2	5	5	1	4	4	0	1.10	3
1796.02653	.41-2	(3.7)	0.0517	(4.0)	2	5	5	1	5	4	2	1.04	8
3580.09269	.21-2	(4.8)	0.0504	(3.1)	3	5	5	1	6	5	2	0.96	4
3870.1283	3.25+0	(4.6)	0.0547	(4.2)	3	6	0	6	5	0	5	1.01	5
1715.1551	1.71+0	(0.4)	0.0479	(0.7)	2	6	0	6	5	1	5	0.98	5
3768.6884	1.49-2	(5.0)	0.0545	(4.1)	1	6	0	6	5	1	5	1.00	3
1498.87473.75-1		(1.3)	0.0573	(1.1)	2	6	0	6	6	1	5	1.00	5
3642.5644	1.23-1	(1.1)	0.0573	(1.9)	3	6	0	6	6	2	5	o.%	5
3609.2325	1.55+0	(3.3)	0.0467	(2.4)	3	6	0	6	7	0	7	0.95	5
1455.30135	.03-1	(0.5)	0.0417	(0.5)	2	6	0	6	7	1	7	0.99	5
3508.83453.81-2		(0.9)	0.0468	(3.1)	1	6	0	6	7	1	7	o.%	5
3891.2985	2.06+0	(6.3)	0.06%(4.1)		3	6	1	5	5	1	4	1.01	5
126.6978	4.47+0	(4.0)	0.05%	(3.0)	o	6	1	5	5	2	4	0.94	6
1730.05505	.28-1	(0.4)	0.0581	(0.7)	2	6	1	5	5	2	4	1.00	7
%.2100	1.58+0	(3.3)	0.0571	(2.8)	O	6	1	5	6	0	6	0.97	3
1699.5672	2.05-1	(1.0)	0.0568	(1.8)	2	6	1	5	6	0	6	0.98	5
3843.5033	1.43-1	(1.2)	0.0622	(1.2)	3	6	1	5	6	1	6	0.95	5
1543.49035.46-1		(0.5)	0.0661	(0.6)	2	6	1	5	6	2	4	1.00	5
3587.4876	1.46-2	(5.7)	0.0756	(3.2)	1	6	1	5	6	2	4	0.92	5
3641.77767.74-2		(1.2)	0.0635	(1.5)	3	6	1	5	6	3	4	0.96	5
3586.54168.75-1		(2.2)	0.0594	(0.6)	3	6	1	5	7	1	6	0.97	5
1436.6555	2.04-1	(2.2)	0.0533	(3.0)	2	6	1	5	7	2	6	0.99	7
121.9060	3.51+1	(1.7)	0.0502	(3.5)	O	6	1	6	5	0	5	0.97	5
1717.4055	5.01+0	(1.5)	0.0503	(1.8)	2	6	1	6	5	0	5	1.01	5
3770.45464.90-2		(0.3)	0.0535	(1.0)	1	6	1	6	5	0	5	0.93	5
3869.1915	1.11+0	(1.6)	0.0517	(1.8)	3	6	1	6	5	1	5	0.97	5
3652.91074.27-2		(0.4)	0.0620	(4.5)	3	6	1	6	6	1	5	0.96	5
1489.8419	1.03+0	(0.3)	0.0519	(0.7)	2	6	1	6	6	2	5	1.01	7
3562.89072.77-2		(3.8)	0.0561	(1.6)	1	6	1	6	6	2	5	0.98	5
1456.5098	1.50+0	(0.5)	0.0422	(0.9)	2	6	1	6	7	0	7	0.99	5
3509.5587	1.16-1	(1.2)	0.0458	(0.8)	1	6	1	6	7	0	7	0.94	5
3609.33775.25-1		(2.3)	0.0446	(2.1)	3	6	1	6	7	1	7	0.93	5
1260.3435	4.00-2	(4.6)	0.0656	(3.0)	2	6	1	6	7	2	5	1.04	5
4025.3505	4.57-2	(2.6)	0.0814	(2.2)	3	6	2	4	5	0	5	0.99	5
1884.5652	4.73-2	(2.1)	0.0683	(2.7)	2	6	2	4	5	1	5	1.05	10
3904.1874	1.66+0	(1.6)	0.0761	(1.8)	3	6	2	4	5	2	3	0.96	5

1707.2225	1.24-1	(1.9)	0.0638	(2.8)	2	6	2	4	5	3	3	1.00	7
1668.2849	3.41-1	(0.3)	0.0648	(0.9)	2	6	2	4	6	1	5	1.00	7
3797.7866	2.01-1	(1.3)	0.0701	(1.3)	3	6	2	4	6	2	5	0.96	5
1549.6417	4.33-1	(0.4)	0.0663	(0.5)	2	6	2	4	6	3	3	1.01	7
3568.2886	6.46-1	(1.9)	0.0719	(1.0)	3	6	2	4	7	2	5	0.95	5
1394.4963	9.41-2	(6.0)	0.0596	(4.1)	2	6	2	4	7	3	5	1.14	4
1761.8286	1.88+0	(0.3)	0.0625	(0.5)	2	6	2	5	5	1	4	0.99	5
3880.3535	5.28-1	(1.3)	0.0590	(1.6)	3	6	2	5	5	2	4	0.99	5
105.6607	5.57+0	(3.6)	0.0530	(1.7)	o	6	2	5	6	1	6	0.93	6
1714.0337	5.53-1	(0.6)	0.0506	(0.6)	2	6	2	5	6	1	6	0.99	7
3693.7885	3.45-2	(3.0)	0.0708	(3.2)	3	6	2	5	6	2	4	0.98	4
1457.0720	5.70-1	(0.8)	0.0502	(0.9)	2	6	2	5	7	1	6	o.%	5
3495.1756	3.98-2	(1.6)	0.0536	(2.8)	1	6	2	5	7	1	6	0.95	5
3586.9537	2.17-1	(0.9)	0.0568	(1.0)	3	6	2	5	7	'2	6	0.94	5
1318.9294	1.43-1	(2.6)	0.0631	(3.2)	2	6	2	5	7	3	4	1.02	7
4008.5704	5.97-2	(1.1)	0.0738	(1.4)	3	6	3	3	5	1	4	0.99	5
1866.3809	1.82-1	(1.7)	0.0624	(2.5)	2	6	3	3	5	?	4	1.02	12
3892.0013	1.08-1	(0.9)	0.0675	(1.7)	1	6	3	3	5	?	4	0.95	5
3899.2154	6.79-1	(1.6)	0.0672	(1.5)	3	6	3	3	5	3	2	0.96	5
1679.8162	2.59-1	(2.3)	0.0669	(3.2)	2	6	3	3	6	?	4	1.02	7
3705.4365	3.71-2	(5.3)	0.0723	(3.9)	1	6	3	3	6	2	4	1.01	5
3759.0485	2.70-1	(1.5)	0.0653	(0.8)	3	6	3	3	6	3	4	0.94	5
1524.8094	1.93-1	(1.7)	0.0576	(1.7)	2	6	3	3	6	4	2	1.04	7
3598.6016	6.31-2	(0.9)	0.0638	(3.2)	1	6	3	3	7	2	6	0.94	s
3565.6707	3.31-1	(2.1)	0.0706(1.4)		3	6	3	3	7	3	4	0.92	5
1354.8457	8.69-2	(1.5)	0.0581	(2.1)	2	6	3	3	7	4	4	1.04	7
323.6310	4.13+0	(2.7)	0.0631	(2.0)	0	6	3	4	5	0	5	0.97	6
1946.3644	4.81-2	(1.0)	0.0613	(2.0)	2	6	3	4	5	0	5	1.04	5
202.4681	2.21+1	(7.3)	0.0700	(5.6)	O	6	3	4	5	2	3	0.98	6
1825.2016	8.77-1	(0.3)	0.0612	(2.4)	2	6	3	4	5	2	3	1.00	10
3846.3974	2.14-2	(7.4)	0.0735	(0.9)	1	6	3	4	5	2	3	0.89	3
3883.2655	2.76-1	(1.3)	0.0598	(1.2)	3	6	3	4	5	3	3	0.99	5
1661.3711	8.92-2	(0.8)	0.0543	(2.3)	2	6	3	4	5	4	1	1.05	7
%.0709	4.60+0	(2.9)	0.0551	(0.9)	o	6	3	4	6	2	5	0.95	5
1710.8009	5.29-1	(0.2)	0.(1531	(1.1)	2	6	3	4	6	?	5	1.02	5
3?25.6845	6.90-2	(3.8)	0.0662	(2.2)	3	6	3	4	6	3	3	0.95	5
1514.9875	5.66-1	(0.4)	0.0522	(0.2)	2	6	3	4	6	4	3	1.03	4
1489.3024	1.34-1	(1.6)	0.0613	(2.4)	2	6	3	4	7	2	5	1.00	7
3570.5395	1.07-1	(2.2)	0.0588	(0.9)	3	6	3	4	7	3	5	0.95	5
1340.4751	2.45-1	(0.6)	0.0548	(0.7)	2	6	3	4	7	4	3	1.03	6
4044.8573.3.24-2(4.5)			0.0735	(2.6)	3	6	4	2	5	2	3	0.95	5
1895.1973	2.00-1	(1.4)	0.0557	(2.7)	2	6	4	2	5	3	3	1.05	7
3897.97266	.97-2	(2.5)	0.0575	(3.3)	1	6	4	2	5	3	3	0.97	5
3881.02764.31-1		(1.8)	0.0558	(1.0)	3	6	4	2	5	4	1	0.99	5
1737.61669	.80-2	(1.8)	0.0614	(2.4)	2	6	4	2	6	3	3	1.00	7
3740.39164.17-2		(7.2)	0.0659	(1.8)	1	6	4	2	6	3	3	1.02	5
1510.53287	.09-2	(5.1)	0.0480	(4.5)	2	6	4	2	6	5	1	1.12	4
3585.24664,47-2		(3.2)	0.0557	(3.6)	1	6	4	2	7	3	5	0.93	5
3560.1317	?.98-1	(1.6)	0.0594	(0.7)	3	6	4	2	7	4	3	0.97	5
1339.51886	.40-2	(2.3)	0.0474	(2.5)	2	6	4	2	7	5	3	1.13	7
1889.56956.04-1		(0.5)	0.0586	(2.4)	2	6	4	3	5	3	2	1.05	12
3879.9484	1.45-1	(1.4)	0.0537	(1.6)	3	6	4	3	5	4	2	0.99	5
107.7460	3.58+0	(4.1)	0.0551	(3.2)	O	6	4	3	6	3	4	0.92	6
1749.40292	.78-1	(0.5)	0.0535	(1.7)	2	6	4	3	6	3	4	1.02	7
1509.78282	.35-1	(3.8)	0.0'$37	(3.0)	2	6	4	3	6	5	2	1.01	4
3562.31876.89-2		(2.4)	0.0560	(0.9)	3	6	4	3	7	4	4	0.93	5
1338.5461	2.00-1	(0.8)	0.0500	(2.6)	2	6	4	3	7	5	2	1.08	7
1942.7654	1.22-1	(2.0)	0.0502	(1.2)	2	6	5	1	5	4	2	1.08	7
3871.4956	1.18-1	(2.8)	0.0498	(3.8)	3	6	5	1	5	5	0	1.04	5
3724.97263.12-1		(1.7)	0.0502'	(1.1)	3	6	5	1	6	5	2	0.98	5
1507.8214	2.37-2	(5.3)	0.0411	(2.5)	2	6	5	1	6	6	0	0.87	3
1942.5161	3.68-1	(1.1)	0.0502	(2.1)	2	6	5	2	5	4	1	1.08	7
3871.4514	4.37-2	(7.6)	0.0507	(3.7)	3	6	5	2	5	5	1	0.94	5
1796.1325	9.37-2	(2.0)	0.0523	(2.9)	2	6	5	2	6	4	3	1.06	7
3724.8925	1.05-1	(3.3)	0.0482	(1.3)	3	6	5	2	6	5	1	0.97	5
1336.6627	1.32-1	(5.2)	0.0474	(2.3)	2	6	5	2	7	6	1	1.06	5
1339.1484	8.76-2	(1.1)	0.0427	(3.9)	2	6	6	1	7	7	0	0.85	7
3886.0763	7.16-1	(1.8)	0.0463	(1.1)	3	?	0	7	6	0	6	0.96	5
1476.42885	.58-1	(0.2)	0.0499	(0.5)	2	7	0	7	7	1	6	1.02	7
3527.9695	1.35-2	(3.3)	0.0515	(4.7)	1	7	0	7	7	1	6	1.05	5
1436.4802	7.92-1	(0.9)	0.0384	(1.0)	2	7	0	7	8	1	8	1.00	7
3488.02067	.05-2	(2.4)	0.0410	(1.1)	1	7	0	7	8	1	8	0.92	5

3906.0634	4.05-1	(1.4)	0.0598	(1.4)	3	7	1	6	6	1	5	0.97	5
1756.8189	1.15+0	(0.3)	0.0515	(0.2)	2	7	1	6	6	2	5	1.01	5
1723.4867	2.72-1	(0.5;	0.0490	(1.1)	2	7	1	6	7	0	7 1	. 0 0	7
3762.17067	.00-3	(6.4)	0.0564	(3.3)	1	7	1	6	7	0	7	1.03	4
1527.3204	7.15-1	(0.1)	0.0613	(0.2)	2	7	1	6	7	?	5	1.02	7
3566.0787	1.47-1	(2.9)	0.0532	(2.7)	3	7	1	6	8	1	7 0	. 9 4	5
1424.13003	.10-1	(0.3)	0.0473	(1.2)	2	7	1	6	8	?	7 0	. 9 8	7
3462.81262	.82-2	(4.2)	0.0490	(4.0)	1	7	1	6	8	?	7 0	. 9 4	5
1734.3933	1.16+0	(0.3)	0.0428	(0.3)	2	7	1	7	6	0	6	0.99	5
3885.6583	2.09+0	(5.6)	0.0472	(1.7)	3	7	1	7	6	1	6 0	. 9 9	3
3628.69766.38-2		(3.5)	0.0553	(4.0)	3	7	1	7	7	1	6 0	. 9 5	5
1471.4817	1.79-1	(0.3)	0.0464	(0.7)	2	7	1	7	7	?	6	1.02	5
1437.02622.63-1		(1.7)	0.0375	(1.2)	2	7	1	7	8	0	8	1.01	7
3488.31872.36-2		(7.1)	0.0466	(2.3)	1	7	1	7	8	'(I	8	0.91	5
3588.74868.26-1		(4.6)	0.0423	(2.0)	3	7	1	7	8	1	8 0	. %	5
1945.34034.85-2		(2.4)	0.0643	(3.3)	2	7	2	5	6	1	6	1.03	5
133.4303	2.67+0	(2.9)	0.0631	(1.9)	0	7	2	5	6	3	4	0.94	6
1688.3785	3.99-1	(0.3)	0.0594	(0.8)	2	7	2	5	7	1	6 1	. 0 1	7
1550.23606	.84-1	(0.2)	0.0667	(0.5)	2	7	2	S	7	3	4	1.02	7
3S45.03579.48-2		(1.9)	0.0674	(0.6)	3	7	2	5	8	2	6 0	. %	5
1386.4766	1.38-1	(2.2)	0.0583	(2.2)	2	7	2	5	8	3	6	1.02	7
166.7054	5.58+0	(3.9)	0.0551	(2.1)	0	7	2	6	6	1	5	0.97	5
1775.63424.13-1		(0.2)	0.0538	(1.1)	2	7	2	6	6	1	5 1	. 0 0	7
3899.4404	1.11+0	(1.9)	0.0548	(1.S)	3	7	2	6	6	?	5 0	. 9 9	5
3866.10856	.20-2	(2.1)	0.0526	(1.9)	3	7	2	6	7	0	7	0.97	5
123.1307	1.28+0	(2.5)	0.0481	(1.7)	0	7	2	6	7	1	7	0.92	5
1732.06088	.64-2	(1.4)	0.0452	(1.5)	2	7	2	6	7	1	7	1.00	7
1501.8457	1.71-1	(1.9)	0.0503	(2.9)	2	7	2	6	7	3	5	1.03	7
1435.64%	9.70-2	(2.1)	0.0443	(2.2)	2	7	2	6	8	1	7	1.01	7
3566.7514	4.06-1	(1.9)	0.0497	(0.9)	3	7	2	6	8	2	7	0.94	5
289.4454	9.71+0	(1.1)	0.0650	(1.2)	0	7	3	4	6	2	5	0.95	4
1909.9640	1.87-1	(0.7)	0.0623	(2.3)	2	7	3	4	6	2	5	1.05	12
3932.0795	2.43-2	(7.6)	0.0673	(5.4)	1	7	3	4	6	2	5	0.99	5
1706.15058.02-2		(2.0)	0.0602	(4.3)	2	7	3	4	6	4	3	1.03	5
1680.4655	4.07-1	(0.8)	0.0671	(1.4)	2	7	3	4	7	2	5	1.02	7
3702.5815	2.55-2	(1.7)	0.0717	(3.6)	1	7	3	4	7	2	5	0.99	4
1531.63823.49-1		(0.7)	0.0611	(1.2)	2	7	3	4	7	4	3	1.02	7
3536.52456.67-2		(6.5)	0.0717	(2.4)	3	7	3	4	8	3	5	0.93	5
1340.1668	9.55-2	(3.8)	0.0581	(3.6)	2	7	3	4	8	4	5	1.06	4
1837.1811	1.60-1	(0.7)	0.0631	(2.2)	2	7	3	5	6	2	4	1.06	5
3904.2934	5.13-1	(4.0)	0.0512	(3.7)	3	7	3	5	6	3	4	1.02	5
3849.05763.44-2		(1.5)	0.0585	(4.6)	3	7	3	5	7	1	6	0.98	4
107.09009.75-1		(2.9)	0.0511	(2.8)	0	7	3	5	7	2	6	0.93	3
1730.34638.67-2		(1.2)	0.0496	(1.4)	2	7	3	5	7	2	6	1.02	7
3710.91567.15-2		(3.4)	0.0631	(4.0)	3	7	3	5	7	3	4	0.98	5
1512.2106	1.06-1	(3.3)	0.0515	(3.8)	2	7	3	5	7	4	4	1.04	5
3547.1566	1.73-1	(2.3)	0.0558	(1.0)	3	7	3	5	8	3	6	0.95	5
1308.17882.,65-2		(5.5)	0.0556	(4.5)	2	7	3	5	8	4	4	1.08	6
282.2586	1.61+1	(1.6)	0.0564	(2.6)	0	7	4	3	6	3	4	0.95	5
1923.16062	.66-1	(0.8)	0.05601	(2.6)	2	7	4	3	6	3	4	1.07	12
3923.4654	9.73-2	(1.4)	0.0592	(1.2)	1	7	4	3	6	3	4	0.97	5
3905.36%	9.11-2	(2.6)	0.0595	(1.0)	3	7	4	3	6	4	2	1.00	5
3868.2303	9.45-3	(3.4)	0.0688	(3.3)	1	7	4	3	7	1	6	0.91	3
88.8804	1.40+0	(3.2)	0.0631	(3.1)	0	7	4	3	7	3	4	0.96	4
1729.7826	1.66-1	(0.5)	0.0627	(1.0)	2	7	4	3	7	3	4	1.04	7
3566.32865.01-2		(3.0)	0.0595	(2.2)	1	7	4	3	8	3	6 0	. 9 3	5
3531.37363	.30-2	(3.1)	0.0649	(5.2)	3	7	4	3	8	4	4	0.94	5
1316.9724	7.65-2	(1.8)	0.0527	(3.5)	2	7	4	3	8	5	4	1.08	7
1907.9591	9.77-2	(2.5)	0.0516	(3.6)	2	7	4	4	6	3	3	1.03	10
3902.4394	1.85-2	(3.4)	0.0786	(2.2)	1	7	4	4	6	3	3	0.90	3
3902.2485	2.83-1	(2.1)	0.0550	(0.8)	3	7	4	4	6	4	3	0.99	5
1752.81375.05-2		(2.5)	0.0515	(4.0)	2	7	4	4	7	3	5	1.03	7
3727.7365	1.26-1	(2.1)	0.0579	(0.7)	3	7	4	4	7	4	3	0.96	5
1509.8613	4.74-2	(3.3)	0.0480	(2.7)	2	7	4	4	7	5	3	1.06	4
3536.26479.95-2		(2.2)	0.0569	(4.1)	3	7	4	4	8	4	5	0.95	5
1313.5964	2.65-2	(3.3)	0.0521	(4.9)	2	7	4	4	8	5	3	1.03	7
303.1106	1.53+1	(4.8)	0.0524	(3.2)	0	7	5	2	6	4	3	0.98	6
1967.4424	1.75-1	(0.8)	0.0525	(2.9)	2	7	5	2	6	4	3	1.07	11
3939.1106	1.71-2	(2.6)	0.0557	(1.6)	1	7	5	2	6	4	3	1.00	3
3894.28663.54-2		(2.4)	0.0516	(2.8)	3	7	5	2	6	5	1	1.01	5
128.5980	1.33+0	(2.5)	0.0551	(1.6)	0	7	5	2	7	4	3	0.91	4
1792.9300	5.80-2	(2.6)	0.0518	(5.4)	2	7	5	2	7	4	3	1.07	5

3764.5976	1.96-2	(0.9)	0.0596	(5.4)	1	7	5	2	7	4	3	0.95	3
3723.27143	.72-2	(1.9)	0.0521	(3.1)	3	7	5	2	7	5	3	1.01	5
1507.97265.42-2		(4.2)	0.0522	(1.8)	2	7	5	2	7	6	1	0.95	5
1312.55574.98-2		(2.5)	0.0504	(2.0)	2	7	5	2	8	6	3	1.07	7
301.8668	5.12+0	(4.3)	0.0532	(4.6)	0	7	5	3	6	4	2	0.97	5
1966.26135	.98-2	(1.7)	0.0543	(2.4)	2	7	5	3	6	4	2	1.05	8
3894.0625	1.10-1	(2.8)	0.0541	(1.1)	3	7	5	3	6	5	2	0.98	5
3722.8254	1.17-1	(4.0)	0.0513	(3.4)	3	7	5	3	‘7	5	2	o.%	s
1507.8516	1.77-2	(2.0)	0.0478	(4.1)	2	7	5	3	7	6	2	0.97	4
327.5948	1.17+1	(4.4)	0.0489	(2.5)	0	7	6	1	6	5	2	0.98	5
2016.83488.80-2		(4.5)	0.0488	(0.9)	2	7	6	1	6	5	2	1.07	5
1845.5981	1.62-2	(4.4)	,0.0505	(0.5)	2	7	6	1	7	5	2	1.12	3
327.5568	3.99+0	(5.3)	0.0482	(2.6)	0	7	6	2	6	5	1	0.95	5
2016.79802	.89-2	(4.9)	0.0491	(3.2)	2	7	6	2	6 ’	5	1	1.09	3
3901.8453	1.22+0	(2.5)	0.0420	(1.9)	3	8	0	8	7	0	7	o.%	5
1750.9841	7.28-1	(3.3)	0.0385	(0.8)	2	8	0	8	7	1	7	0.96	5
1454.57298.51-2		(1.2)	0.0434	(1.9)	2	8	0	8	8	1	7	1.04	7
3602.48862	.87-2	(3.1)	0.0466	(2.9)	3	8	0	8	8	2	7	0 . 9 4	5
1417.2532	1.25-1	(1.7)	0.0356	(5.0)	2	8	0	8	9	1	9	1.02	6
3467.14567.24-3		(6.4)	0.0522	(4.7)	1	8	0	8	9	1	9	0.98	4
3920.08766.31-1		(1.6)	0.0521	(1.0)	3	8	1	7	7	1	6	0.96	5
173.2838	3.24+0	(3.0)	0.0466	(1.3)	0	8	1	7	7	2	6	0.97	6
1780.74592.31-1		(1.4)	0.0456	(?.7)	2	8	1	7	7	2	6	1.02	7
1746.2905	3.57-2	(3.3)	0.0442	(4.9)	2	8	1	7	8	0	8	1.07	7
1507.44238.62-2		(2.2)	0.0511	(0.5)	2	8	1	7	8	2	6	1.13	4
3545.2215	1.94-1	(2.4)	0.0476	(1.7)	3	8	1	7	9	1	8	0.93	5
1409.96864.65-2		(1.1)	0.0428	(2.5)	2	8	1	7	9	2	8	0.99	7
1751.4233	2.09+0	(0.5)	0.0389	(0.9)	2	8	1	8	7	{ ,	7	1.01	5
3901.66544.08-1		(2.2)	0.0425	(1.8)	3	8	1	8	7	1	7	0.95	5
1452.06662.51-1		(0.7)	0.0426	(2.0)	2	8	1	8	8	2	7	1.04	7
1417.4984	3.77-1	(0.2)	0.0349	(3.6)	2	8	1	8	9	0	9	1.01	7
3942.65154.13-1		(1.6)	0.0673	(0.7)	3	8	2	6	7	2	5	0.97	5
166.21679	.29-1	(4.5)	0.0597	(4.3)	0	8	2	6	7	3	5	0.92	4
1779.11866.79-2		(2.0)	0.0556	(3.0)	2	8	2	6	7	3	5	0.97	6
1712.92264.76-2		(2.1)	0.0552	(3.4)	2	8	2	6	8	1	7	1.00	7
3839.46043.05-2		(3.1)	0.0633	(1.8)	3	8	2	6	8	?	7	O.%	5
1545.65529	.57-2	(5.0)	0.0637	(s.3)	2	8	2	6	8	3	5	1.03	5
3523.13971.13-1		(2.6)	0.0628	(1.4)	3	8	2	6	9	?	7	0.95	5
181.3890	1.08+1	(6.5)	0.0499	(5.7)	0	8	2	7	7	1	6	0.99	6
1790.%187.19-1		(0.2)	0.0478	(0.8)	2	8	2	7	7	1	6	1.02	5
3916.32762.05-1		(1.0)	0.0493	(2.1)	3	8	2	7	7	?	6	0.95	5
141.4386	2.19+0	(4.2)	0.0427	(2.9)	0	8	2	7	8	1	8	0.95	6
1489.0499	2.35-1	(0.9)	0.0480	(1.0)	2	8	2	7	8	3	6	1.03	7
1416.0863	1.37-1	(0.4)	0.0418	(0.8)	2	8	2	7	9	1	8	1.00	7
3545.5506	6.32-2	(3.3)	0.0463	(5.6)	3	8	2	7	9	2	8	0.93	5
3949.9824	2.82-1	(1.9)	0.0730	(0.6)	3	8	3	5	7	3	4	0.99	5
1687.87795.29-2		(2.8)	0.0621	(4.1)	2	8	3	5	8	2	6	1.07	7
3509.4195	7.88-2	(2.7)	0.0720	(1.3)	3	8	3	5	9	3	6	0.95	5
223.7061	6.93+0	(3.5)	0.0609	(0.9)	0	8	3	6	7	2	5	0.95	5
1847.7828	2.53-1	(0.4)	0.0615	(0.6)	2	8	3	6	7	2	5	1.06	5
3924.3714	1.00-1	(2.2)	0.0563	(2.7)	3	8	3	6	7	3	5	0.97	5
3858.17446.85-3		(2.5)	0.0598	(3.1)	3	8	3	6	8	1	7	0.93	3
120.5199	1.65+0	(3.9)	0.0491	(1.9)	0	8	3	6	8	2	7	0.91	3
1744.5924	1.08-1	(2.0)	0.0471	(2.1)	2	8	3	6	8	2	7	1.04	7
1507.4841	1.62-1	(3.1)	0.0520	(0.9)	2	8	3	6	8	4	5	0.97	5
1428.2711	4.38-2	(1.9)	0.0534	(2.1)	2	8	3	6	9	2	7	1.01	7
3524.83362.79-2		(3.3)	0.0504	(4.6)	3	8	3	6	9	3	7	0 . 9 4	5
315.0820	2.40+0	(3.8)	0.0590	(3.0)	0	8	4	4	7	3	5	0.94	4
1954.99593.50-2		(3.3)	0.0568	(1.9)	2	8	4	4	7	3	5	1.02	5
3930.5644	1.36-1	(2.0)	‘0.0629	(1.4)	3	8	4	4	7	4	3	0.99	5
280.3521	6.86+0	(3.8)	0.0636	(2.9)	0	8	4	5	7	3	4	0 . 9 5	4
1922.3409	1.25-1	(0.9)	0.0640	(2.3)	2	8	4	5	7	3	4	1.05	11
3923.7924	4.97-2	(2.1)	0.0586	(5.9)	3	8	4	5	7	4	4	0.99	5
1704.8621	1.48-2	(5.4)	0.0542	(3.5)	2	8	4	5	7	5	2	1.13	3
1758.5816	6.81-2	(2.1)	0.0505	(3.7)	2	8	4	5	8	3	6	1.05	7
1509.53077.13-2		(4.4)	0.0498	(5.4)	2	8	4	5	8	5	4	1 . 0 8	5
328.1683	2.47+0	(4.9)	0.0558	(2.7)	0	8	5	3	7	4	4	0 . 9 5	5
1992.3882	2.37-2	(1.4)	0.0509	(3.5)	2	8	5	3	7	4	4	1.11	4
3917.2075	5.77-2	(6.7)	0.0545	(3.3)	3	8	5	3	7	5	2	1.09	5
3721.8764	3.69-2	(6.4)	0.0550	(4.3)	3	8	5	3	8	5	4	0 . 9 9	5
3499.7457	1.93-2	(4.7)	0.0631	(3.8)	3	8	5	3	9	5	4	0.96	4
323.9295	7.18+0	(4.4)	0.0571	(2.2)	0	8	5	4	7	4	3	0.96	6

1988.3959	7.50-2	(0.8)	0.0560	(2.3)	2	8 5 4	7 4 3	1.06	7
1796.92453	.14-2	(2.7)	0.0566	(4.2)	2	8 5 4	8 4 5	0.99	5
1508.02162.67-2		(5.1)	0.0494	(4.8)	2	8 5 4	8 6 3	1.10	4
2041.4956	1.29-2	(3.1)	0.0547	(2.3)	2	8 6 2	7 5 3	1.02	3
2041.2884	3.62-2	(4.7)	0.0499	(4.5)	2	8 6 3	7 5 2	1.10	6
3917.3614	2.06-1	(2.5)	0.0382	(4.3)	3	9 0 9	8 0 8	O.%	5
1768.1202	1.13+0	(0.3)	0.0359	(0.4)	2	9 0 9	8 1 8	1.02	5
1433.2033	1.09-1	(0.7)	0.0413	(1.9)	2	9 0 9	9 1 8	1.04	7
1397.7329	1.61-1	(0.5)	0.0338	(0.9)	2	9 0 9 ”	1 0 1 1 0	1.02	7
3934.0995	9.77-2	(1.7)	0.0472	(1.2)	3	9 1 8	8 1 7	O.%	5
193.4811	5.97+0	(5.4)	0.0432	(3.6)	O	9 1 8	8 2 7	0.98	6
1802.47973	.65-1	(0.2)	0.0425	(1.3)	2	9 1 8	8 2 7	1.03	10
1486.1584	1.03-1	(2.3)	0.0497	(2.7)	2	9 1 8	9 2 7	1.06	7
3523.9704	2.64-2	(3.8)	0.0417	(4.0)	3	9 1 8	10 ‘1 9	0.91	5
1768.3121	3.79-1	(0.2)	0.0356	(1.1)	2	9 1 9	8 0 8	1.01	5
3917.28436	.32-1	(2.1)	0.0402	(0.8)	3	9 1 9	8 1 8	0 . 9 4	5
1431.99023	.76-2	(1.3)	0.0383	(3.6)	2	9 1 9	9 2 8	1.00	3
1397.8434	5.29-2	(1.2)	0.0334	(2.5)	2	9 1 9	10 0 10	1.04	7
3956.8815	5.65-2	(2.5)	0.0625	(0.9)	3	9 2 7	8 2 6	0.97	5
1812.2821	1.06-1	(1.0)	0.0538	(3.6)	2	9 2 7	8 3 6	1.04	10
1535.6790	1.01-1	(2.5)	0.0617	(3.0)	2	9 2 7	9 3 6	1.03	7
1807.7033	1.23-1	(0.6)	0.0440	(3.5)	2	9 2 8	8 1 7	1.03	10
3932.1344	2.90-1	(2.0)	0.0462	(1.8)	3	9 2 8	8 ? 7	0.96	5
3897.5653	1.21-2	(2.4)	0.0476	(0.9)	3	9 2 8	9 0 9	0.96	3
1474.36233.08-2		(2.5)	0.0464	(5.7)	2	9 2 8	9 3 7	1.06	5
1397.5754	1.77-2	(6.0)	0.0396	(4.9)	2	9 2 8	10 1 9	1.04	6
3524.10077.84-2		(3.6)	0.0435	(3.5)	3	9 2 8	10 ? 9	0.91	5
3972.1224	3.93-2	(3.2)	0.0719	(1.6)	3	9 3 6	8 3 5	0.99	5
1781.96192.79-2		(2.9)	0.0644	(s.0)	2	9 3 6	8 4 5	1.05	5
1702.74895	.15-2	(1.7)	0.0588	(5.3)	2	9 3 6	9 ? 7	1.06	7
1544.4351	6.92-2	(2.4)	0.0614	(4.5)	2	9 3 6	9 4 5	1.08	5
3942.8854	1.41-1	(2.1)	0.0556	(1.2)	3	9 3 7	8 3 6	0.97	5
3502.87363.37-2		(5.1)	0.0498	(5.0)	3	9 3 7	10 3 8	0.96	5
1992.6504	2.91-2	(1.8)	0.0558	(4.4)	2	9 4 5	8 3 6	1.14	5
3944.36636	.57-2	(2.3)	0.0584	(3.6)	3	9 4 6	8 4 5	1.00	5
3485.7396	1.52-2	(3.9)	0.0571	(3.5)	3	9 4 6	1 0 4 7	0.97	3
2018.3375	2.68-2	(1.4)	0.0543	(1.7)	2	9 5 4	8 4 5	1.08	4
3938.2885	2.94-2	(3.7)	0.0559	(2.8)	3	9 5 5	8 5 4	1.01	5
3932.5795	2.88-1	(4.4)	0.0372	(2.9)	3	10 0.10	9 0 9	0.95	5
1784.8869	1.84-1	(0.4)	0.0350	(0.6)	2	10 0 10	9 1 9	1.02	5
1412.0787	1.44-2	(5.4)	0.0408	(5.1)	2	10 0 10	1 0 1 9	1.02	5
1784.97135.48-1		(0.2)	0.0344	(1.2)	2	10 1 10	9 0 9	1.03	5
3932.5444	9.%-2	(7.7)	0.0375	(1.6)	3	10 1 10	9 1 9	0.95	5
1411.50564	.13-2	(2.2)	0.0376	(4.5)	2	10 1 10	1 0 2 9	1.07	7
3948.1754	1.23-1	(2.3)	0.0441	(1.4)	3	1 0 1 9	9 1 8	o.%	5
1822.76065.66-2		(1.8)	0.0428	(5.0)	2	1 0 1 9	9 2 8	1.04	10
1465.1775	1.19-2	(2.9)	0.0459	(3.4)	2	1 0 1 9	1 0 2 8	1.06	3
3969.13736	.>9-2	(3.3)	0.0565	(1.6)	3	1 0 2 8	9 2 7	0 . 9 6	5
3480.393611.36-2		(7.6)	0.0512	(4.0)	3	1 0 2 8	11 2 9	0.91	4
1825.3487	1.66-1	(0.9)	0.0419(1.6)		2	1 0 2 9	9 1 8	1.06	10
3947.1735	3.96-2	(1.6)	0.0450	(3.2)	3	1 0 2 9	9 2 8	0.95	5
3990.71134.21-2		(3.6)	0.0721	(4.3)	3	1 0 3 7	9 3 6	0.99	5
1870.80495.15-2		(3.9)	0.0520	(4.6)	2	1 0 3 8	9 2 7	1.12	10
3959.7225	1.88-2	(2.4)	0.0507	(0.6)	3	1 0 3 8	9 3 7	0.99	3
3974.7513	7.53-3	(2.3)	0.0701	(2.9)	1	1 0 5 6	9 4 5	1.07	4
3962.1854	1.50-2	(2.4)	0.0453	(3.9)	3	11 1 10	10 1 9	0.99	5
1842.13077	.40-2	(3.3)	0.0414	(2.3)	2	11 1 10	10 2 9	0.98	5
3961.7114	4.76-2	(6.3)	0.0420	(3.8)	3	11 2 10	10 2 9	0.94	5
3975.1383	2.02-2	(4.3)	0.0483	(5.8)	3	1 1 3 9	10 3 8	0.98	4
1817.46889	.44-2	(5.8)	0.0341	(2.1)	2	12 1 12	11 0 11	1.07	5
W-51.53162.48-2		(3.5)	0.0399	(5.0)	2	12 211	11 1 10	1.08	7

* Positions and intensities are in units of cm-' and cm^{-2}/atm at 296 K respectively. The t1₂-broadened widths are in units of cm^{-1}/atm at the effective temperatures ascribed by the vibrational identification: O = rotational region at 295 K, 1 = ν_1 at 291 K, 2 = ν_2 at 299 K and 3 = ν_3 at 291 K.

Table 4 Comparison with pure rotational width measurements

Study	J' $K_a K_c$ J" $K_a K_c$	Band	Observed γ	Temperature
Liebe and Dillon (1969)	6 1 6 - 5 2 3	Rot	0.0834 (2.5%)	300 K
Kasuga et al. (1978)	6 1 6 - 5 2 3	Rot	0.0710 (11.%)	293 K
Present	5 2 3 - 6 1 6	ν_1	0.0782 (1.9%)	291 K
Dutta et al. (1993)	4 1 4 - 3 2 1	Rot	0.0811 (2.5%)	300 K
Present	3 2 1 - 4 1 4	ν_2	0.0809 (2.2%)	299 K
Dutta et al. (1993)	3 1 3 - 2 2 0	Rot	0.0811 (2.5%)	300 K
Present	3 1 3 - 2 2 0		not measured	

in units of cm^{-1} / atm

Table 5 Comparison with the 1.4 μm width measurements

J' K_a K_c		J" K_a K_c	Band	γ (%unc) Obs.	Temp K	Ratio γ higher vib / γ lower vib
0 0 0	-	1 0 1	$\nu_1+\nu_3$	0.0930 (1.1)	300	1.03
1 0 1	-	0 0 0	ν_3	0.0907 (0.8)	291	
2 1 2	-	2 1 1	$\nu_1+\nu_3$	0.1010 (5.9)	300	1.06
2 1 2	-	2 1 1	ν_3	0.0943 (0.8)	291	
2 1 1	-	2 1 2	ν_3	0.0957 (1.1)	291	
3 2 2	-	3 2 1	$\nu_1+\nu_3$	0.0880 (4.5)	300	1.14
3 2 2	-	3 2 1	ν_3	0.0750 (1.3)	291	
3 2 1	-	3 2 2	ν_3	0.0793 (0.9)	291	
3 3 1	-	3 3 0	$\nu_1+\nu_3$	0.0650 (7.6)	300	1.06
3 3 0	-	3 3 1	$\nu_1+\nu_3$	0.0630 (4.8)	300	
3 3 0	-	3 3 1	ν_3	0.0602 (2..2)	291	
4 3 2	-	4 3 1	$\nu_1+\nu_3$	0.0700 (2.9)	300	1.12
4 3 1	-	4 3 2	$\nu_1+\nu_3$	0.0640 (3.1)	300	
4 3 1	-	4 3 2	ν_3	0.0632 (0.4)	291	
4 3 2	-	4 3 1	ν_3	0.0622 (2.5)	291	
5 3 2	-	5 3 3	$\nu_1+\nu_3$	0.0670 (3.0)	300	
3 2 1	-	3 1 2	$2\nu_1$	0.0860 (%5)	300	1.07
3 2 1	-	3,1 2	ν_1	0.0794 (3.1)	291	
3 1 2	-	3 2 1	ν_1	0.0832 (1.1)	291	1.02
3 2 1	-	3 1 2	ν_2	0.0803 (0.8)	299	
3 1 2	-	3 2 1	ν_2	0.0806 (1.1)	299	
4 2 2	-	4 1 3	$2\nu_1$	0.1230 (8.1)	300	1.62
4 1 3	-	4 2 2	ν_1	0.0824 (4.3)	291	1.09
4 2 2	-	4 1 3	ν_2	0.0762 (1.1)	299	
4 1 3	-	4 2 4	ν_2	0.0753 (0.8)	299	
5 2 3	-	5 1 4	$2\nu_1$	0.1040 (4.8)	300	1.45
5 2 3	-	5 1 4	ν_1	0.0762 (2.4)	291	
5 1 4	-	5 2 3	ν_1	0.0767 (1.8)	291	1.06
5 2 3	-	5 1 4	ν_2	0.0717 (0.4)	299	
5 1 4	-	5 2 3	ν_2	0.0721 (0.7)	299	

FIGURE CAPTIONS

Fig. 1 The spectrum of Hz-broadened H_2O in the ν_2 region recorded at 0.0056 cm^{-1} resolution with Kitt Peak FTS. The optical path is 1.5 m. The pressures of H_2O and H_2 are 0.52 and 447 Torr, respectively, at 290 K. .

Fig. 2 The retrieval of measurements by curve-fitting. Observed and synthetic spectra are overlaid and the differences between the two plotted separately. The upper frame shows a feature consisting of a Lorentzian component from the 764 Torr of hydrogen mixed with water in the absorption cell and a narrow component arising from 0.015 Torr of residual water inside the FTS enclosure. The lower frame illustrates the case in which several transitions must be fitted simultaneously for the 993 Torr spectrum.

Fig. 3 The ratios of H_2-H_2O widths for 79 pairs of transitions with rotational quanta reversed. The ratios are plotted as a function of the maximum J in the transition; the plot symbol is 1 for v_1 and 3 for ν_3.

Fig. 4 Composite of all observed widths in cm-l/ atm at room temperature as a function of km (maximum Ka) with jm (maximum J) as the plotting symbol. The small (km-jm) term is used to offset the plot symbols. P branch transitions are underlined.

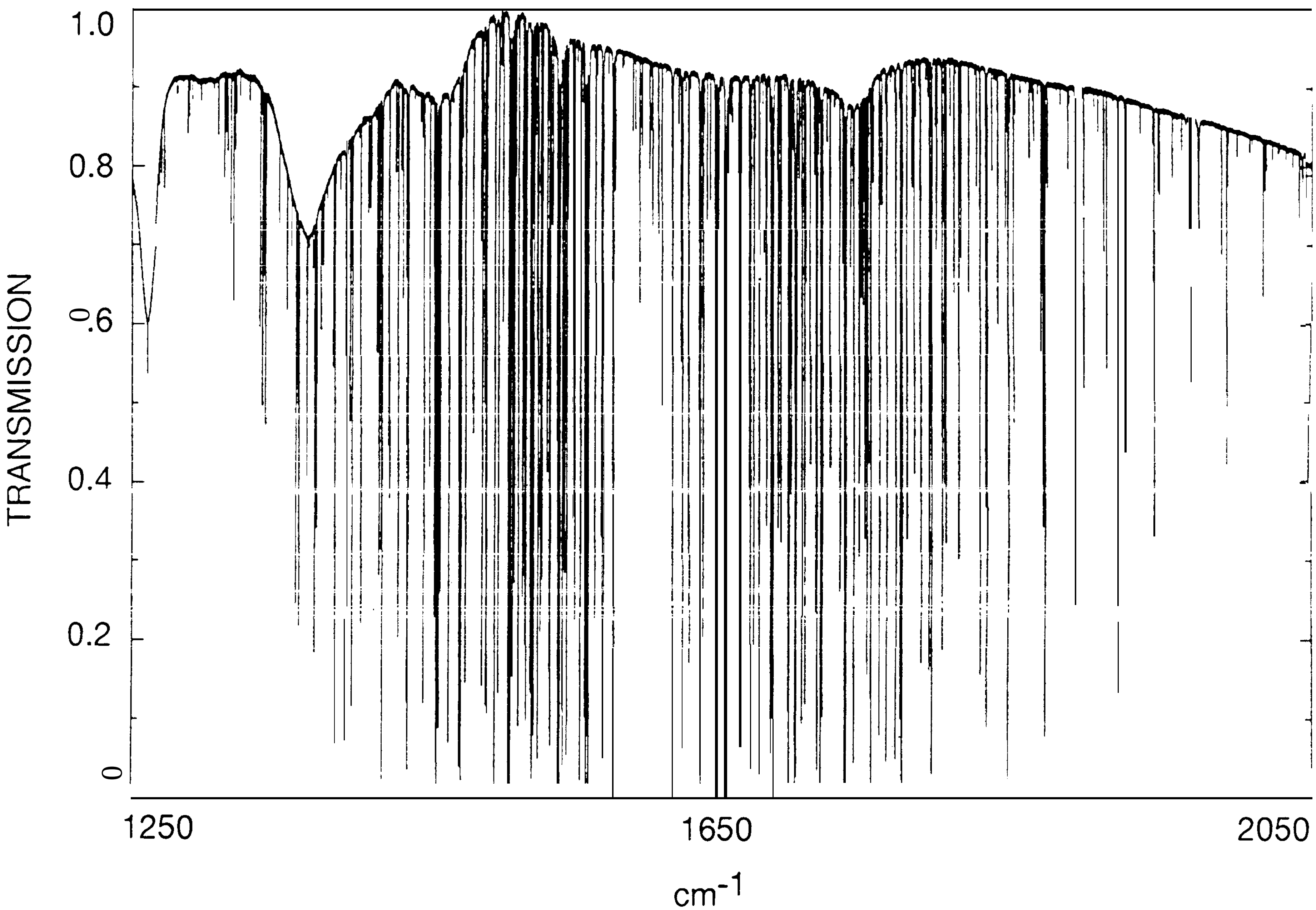
Fig. S The variation of the km = 2 widths as a function of jm with the value of Ka+Kc-J = O or 1 as the plot symbol. These are widths of transitions for which the upper and lower state levels are both either Ka + Kc-J = O or 1, as i Illustrated to the right of each frame. Widths of transitions arising from the lower component of each level doublet (plot symbol = 1) are smaller.

TOP: R and P branch transitions of the parallel ν_3 band
BOTTOM: Q branch transitions of the perpendicular ν_2 band.

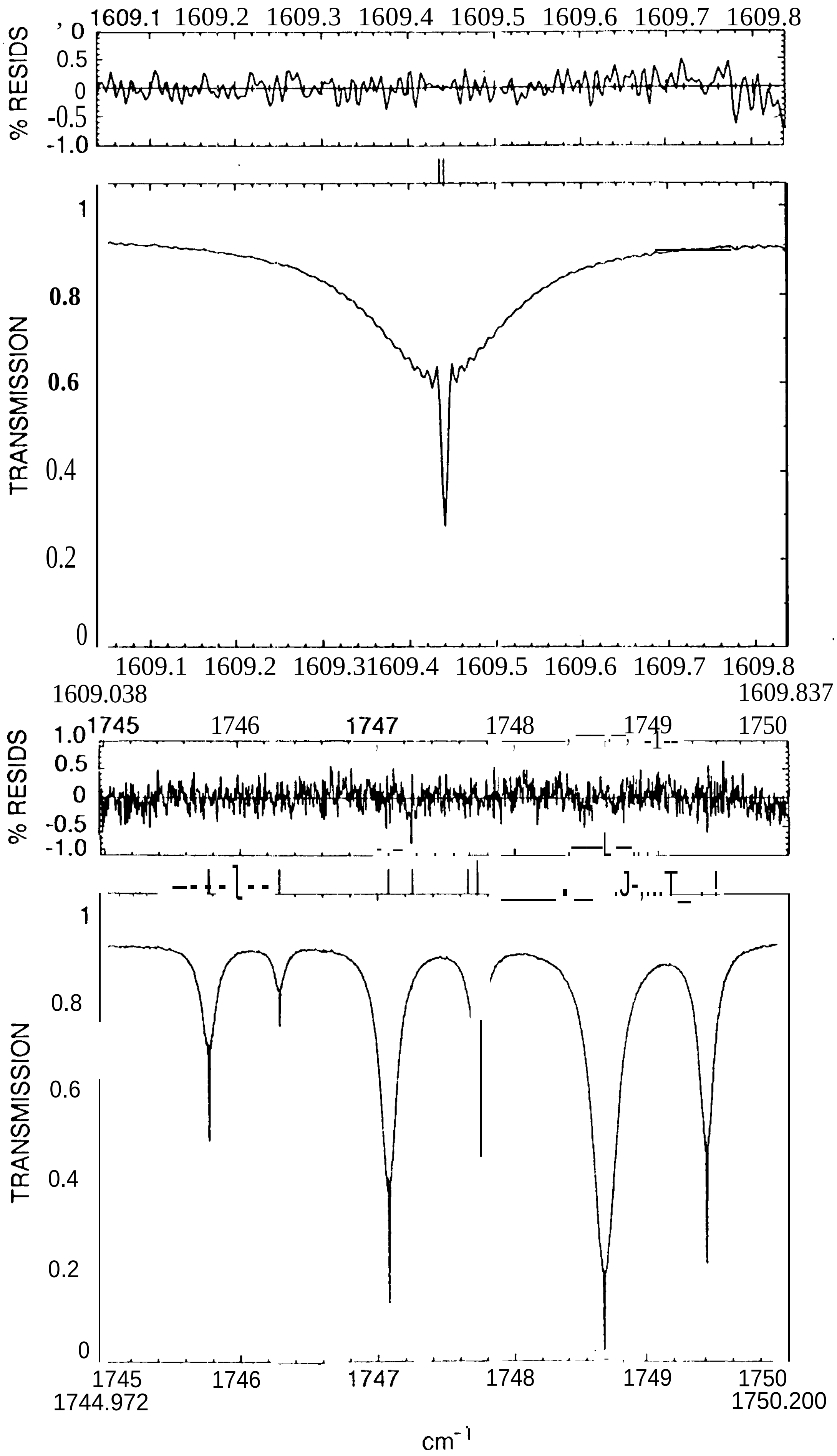
Fig. 6 The variation of the widths for Ka + Kc-J = () transitions for all km (maximum Ka) as a function of jm (maximum J). The plot symbols are km where km = Ka" for AKa = -1 and O or km = Ka+1 for AKa = +1.

TOP: R and P branch transitions of the parallel ν_3 band
BOTTOM: Q branch transitions of the perpendicular ν_2 band.

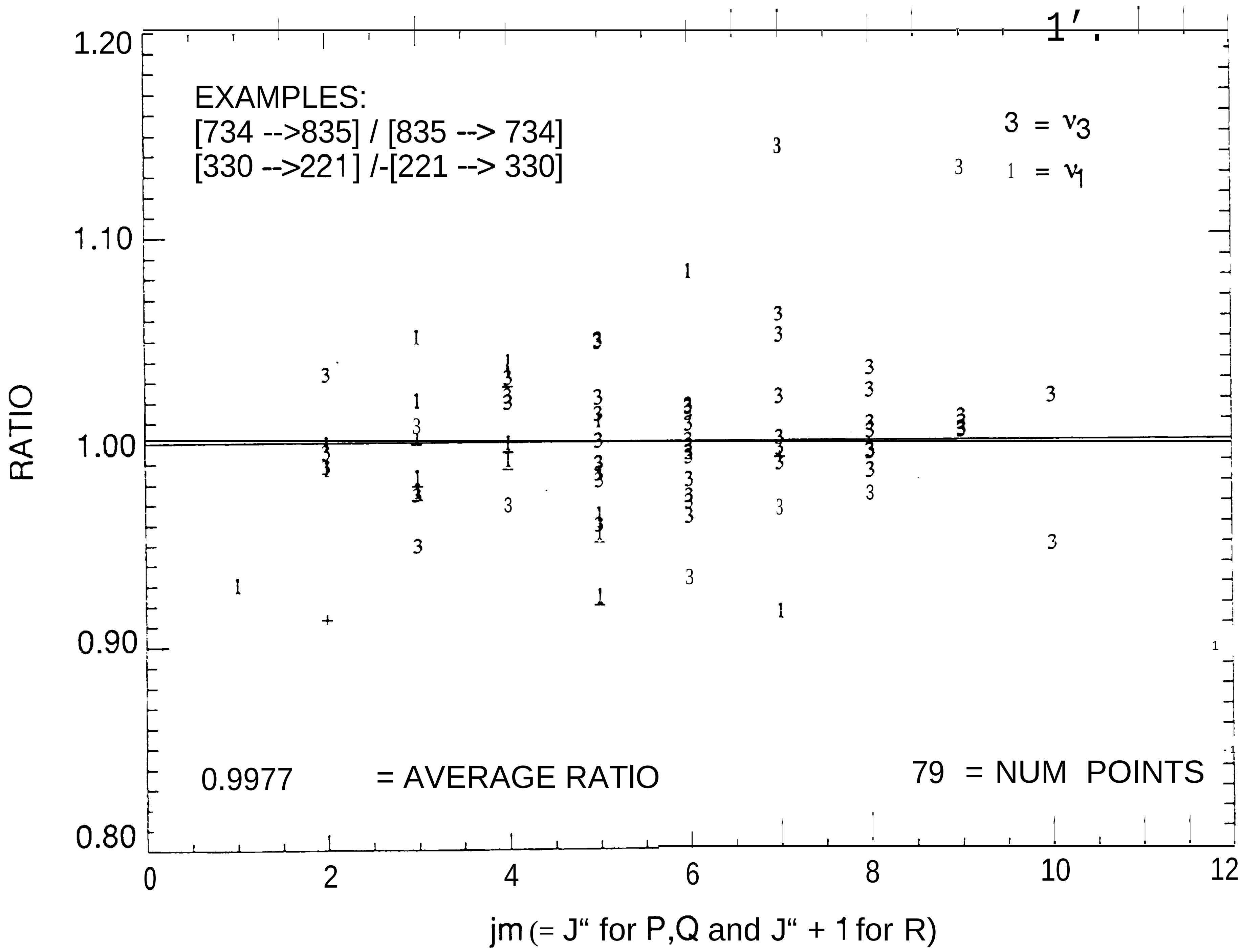
Fig. 7 The ratios of widths as a function of jm for transitions with the same rotational quantum numbers in different perpendicular bands. The widths of ν_2 are the denominator. The plot symbols O and 1 indicate, respectively, that the rotational or ν_1 widths were used for the numerator. The average ratio of rotational to ν_2 widths is 1.016 (* 2.6%) indicating there is small vibrational dependence between the pure rotational and the lowest fundamental bands. The average ratio of v, to ν_2 is 1.08 (* 3,9%) with individual values as large as 1.18 showing that the rotational dependence is not exactly the same for the two infrared fundamentals.



F. 1



% RESIDS
TRANSMISSION
1609.1 1609.2 1609.3 1609.4 1609.5 1609.6 1609.7 1609.8
1609.038
1609.837
1745 1746 1747 1748 1749 1750
1744.972
1750.200
cm^{-1}



1'.
EXAMPLES:
[734 -->835] / [835 --> 734]
[330 -->221] /-[221 --> 330]
3 = ν_3
1 = ν_1
RATIO
1.20
1.10
1.00
0.90
0.80
0.9977 = AVERAGE RATIO
79 = NUM POINTS
0
2
4
6
8
10
12
jm (= J" for P,Q and J" + 1 for R)

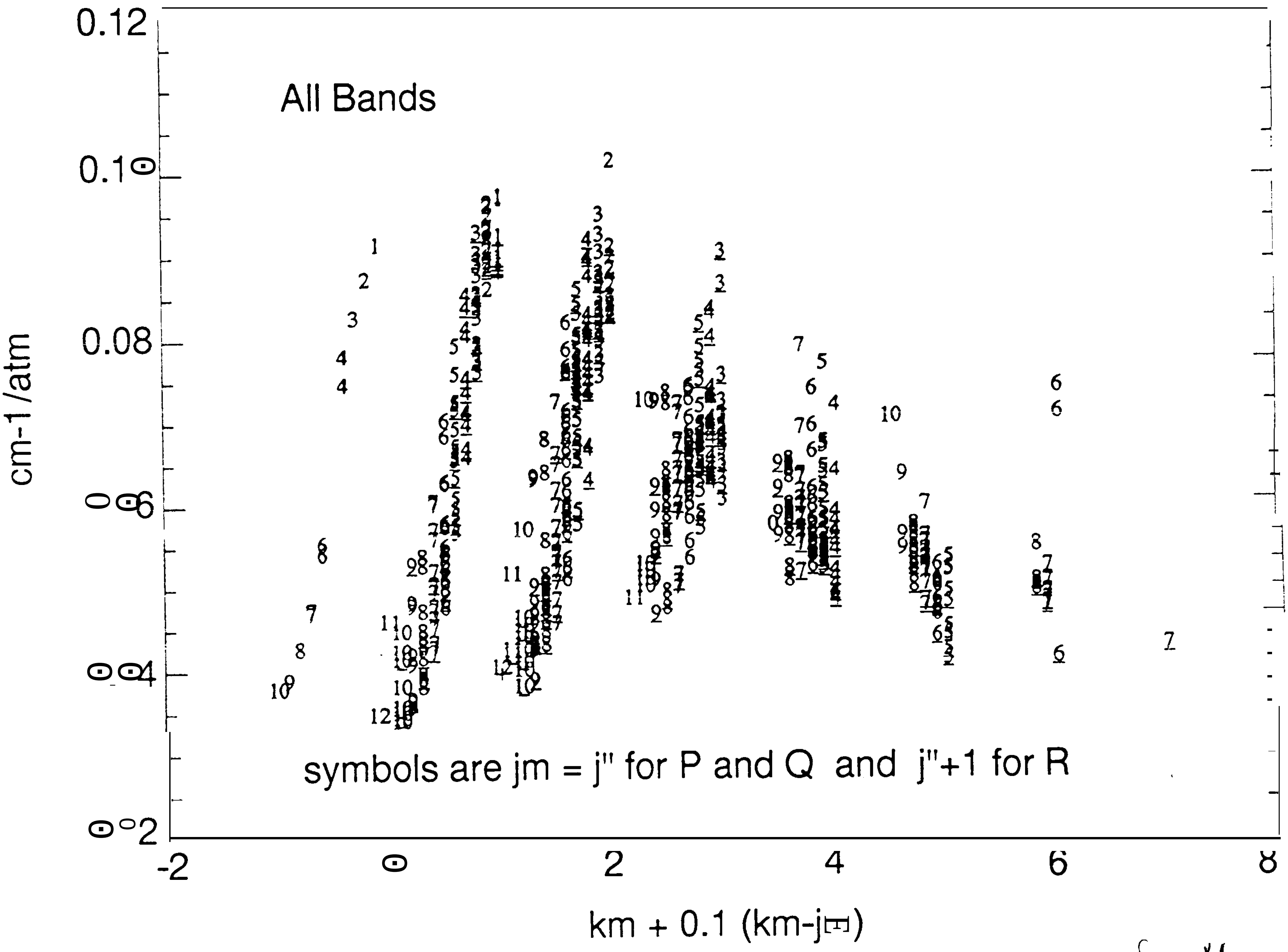
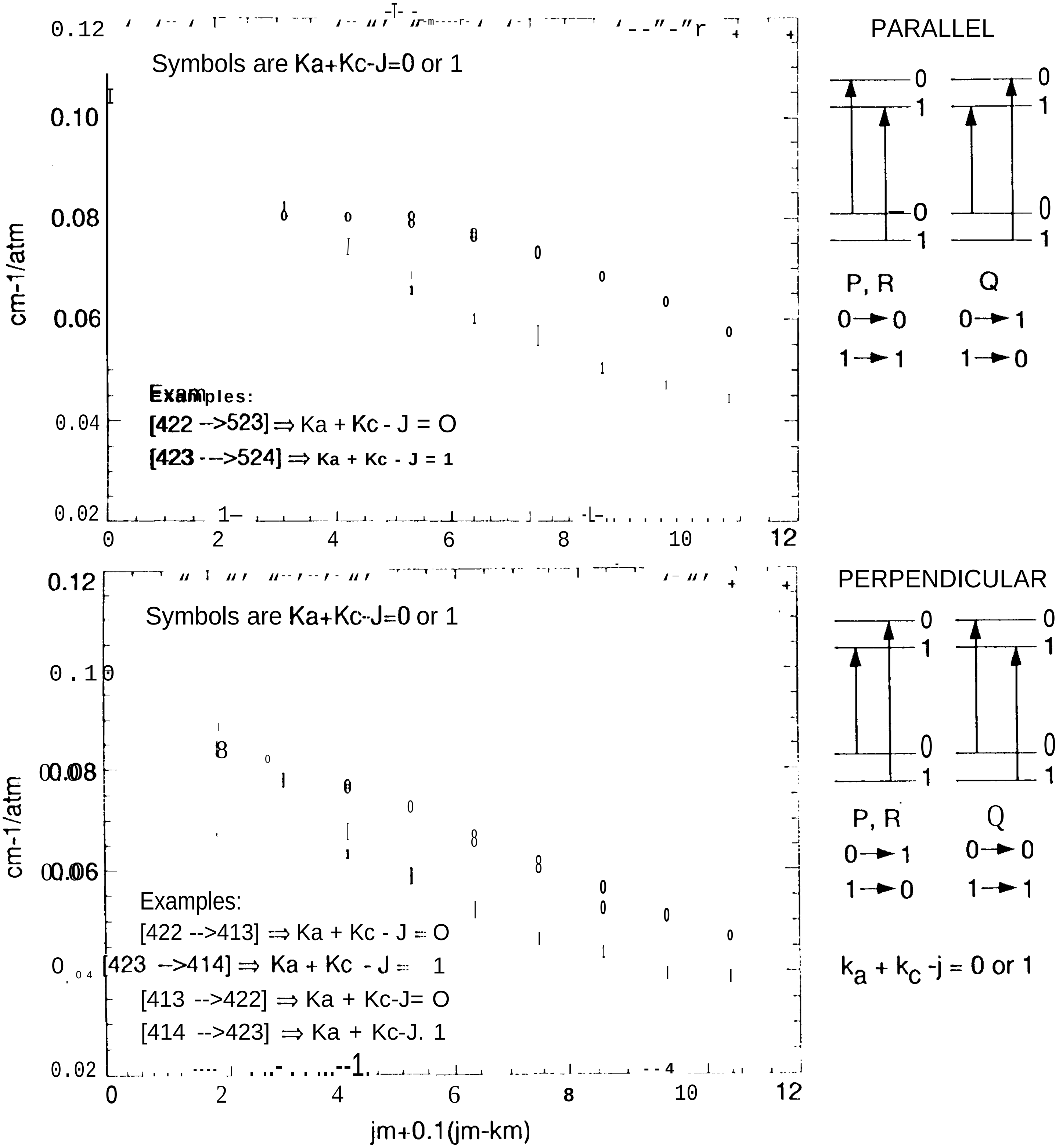
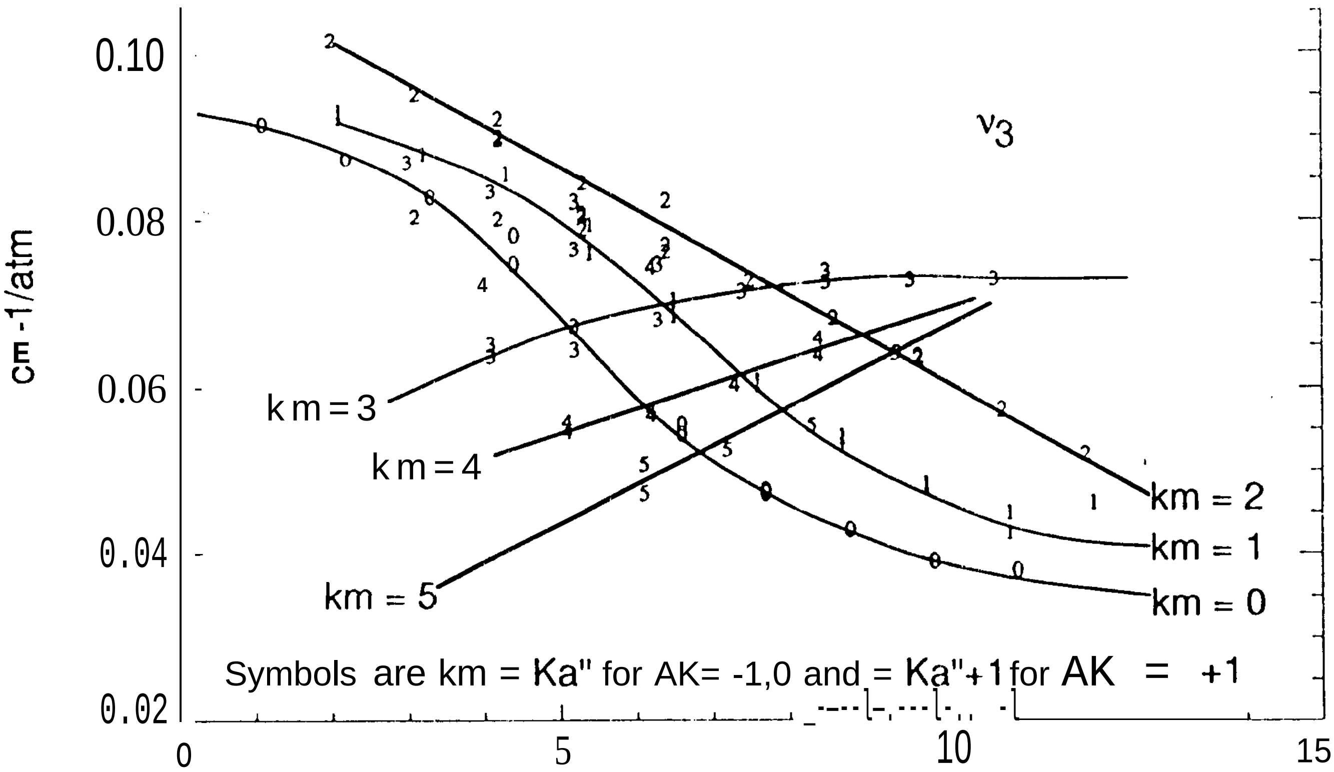

All Bands
symbols are jm = j" for P and Q and j"+1 for R
cm-1 /atm
0.12
0.10
0.08
0.06
0.04
0.02
-2
0
2
4
6
8
km + 0.1 (km-jm)

Fig. 4

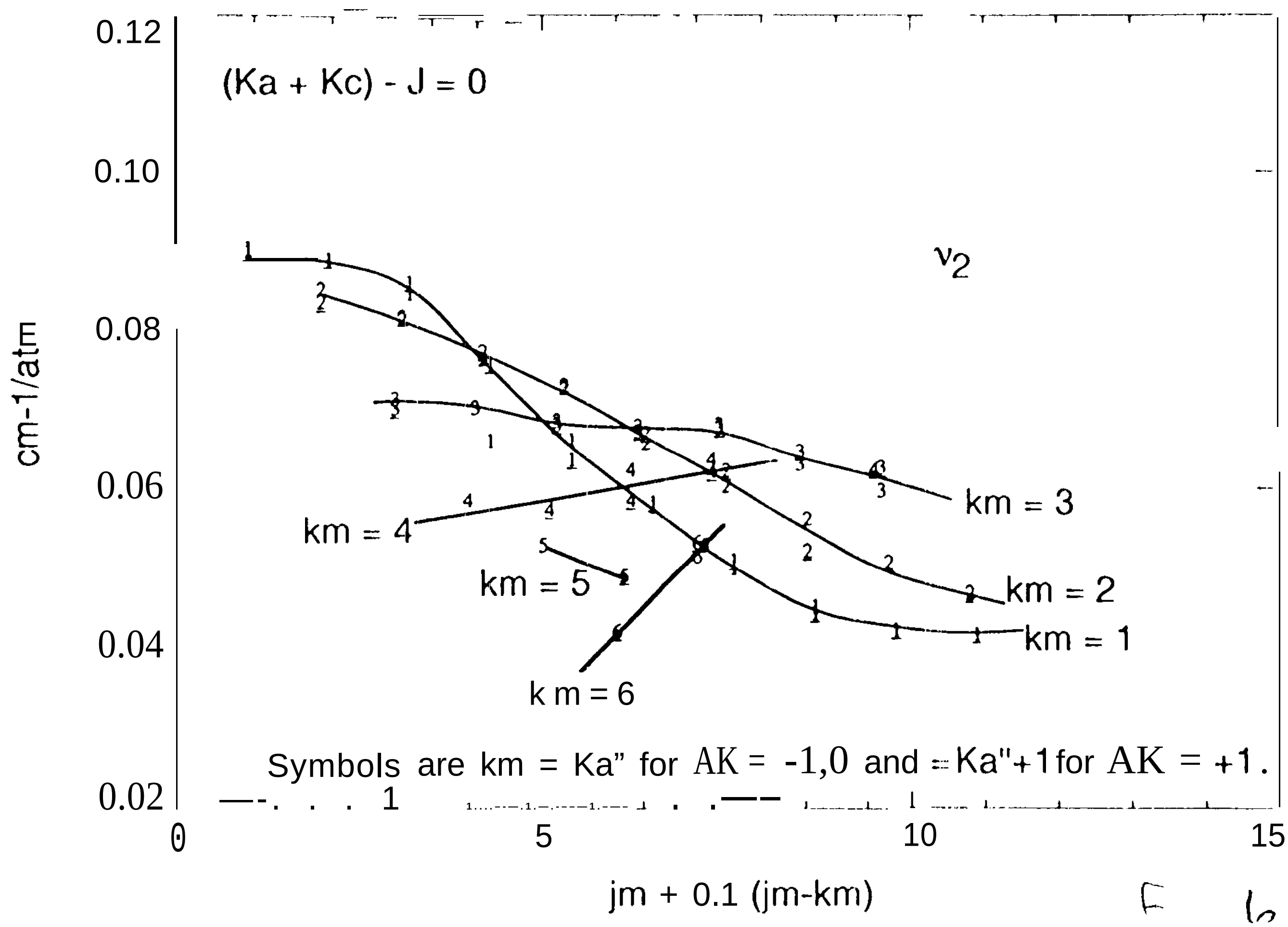


PARALLEL
Symbols are Ka+Kc-J=0 or 1
Examples:
[422 -->523] ⇒ Ka + Kc - J = O
[423 --->524] ⇒ Ka + Kc - J = 1
P, R
0 → 0
1 → 1
Q
0 → 1
1 → 0
cm-1/atm
PERPENDICULAR
Symbols are Ka+Kc-J=0 or 1
Examples:
[422 -->413] ⇒ Ka + Kc - J = O
[423 -->414] ⇒ Ka + Kc - J = 1
[413 -->422] ⇒ Ka + Kc-J= O
[414 -->423] ⇒ Ka + Kc-J. 1
P, R
0 → 1
1 → 0
Q
0 → 0
1 → 1
ka + kc -j = 0 or 1
jm+0.1(jm-km)

5



ν_3
cm-1/atm
0.10
0.08
0.06
0.04
0.02
0
5
10
15
km = 3
km = 4
km = 5
km = 2
km = 1
km = 0
Symbols are km = Ka" for AK= -1,0 and = Ka"+1 for AK = +1



(Ka + Kc) - J = 0
ν_2
cm-1/atm
0.12
0.10
0.08
0.06
0.04
0.02
0
5
10
15
km = 3
km = 4
km = 5
km = 2
km = 1
km = 6
Symbols are km = Ka" for AK = -1,0 and = Ka"+1 for AK = +1.
jm + 0.1 (jm-km)

F 6

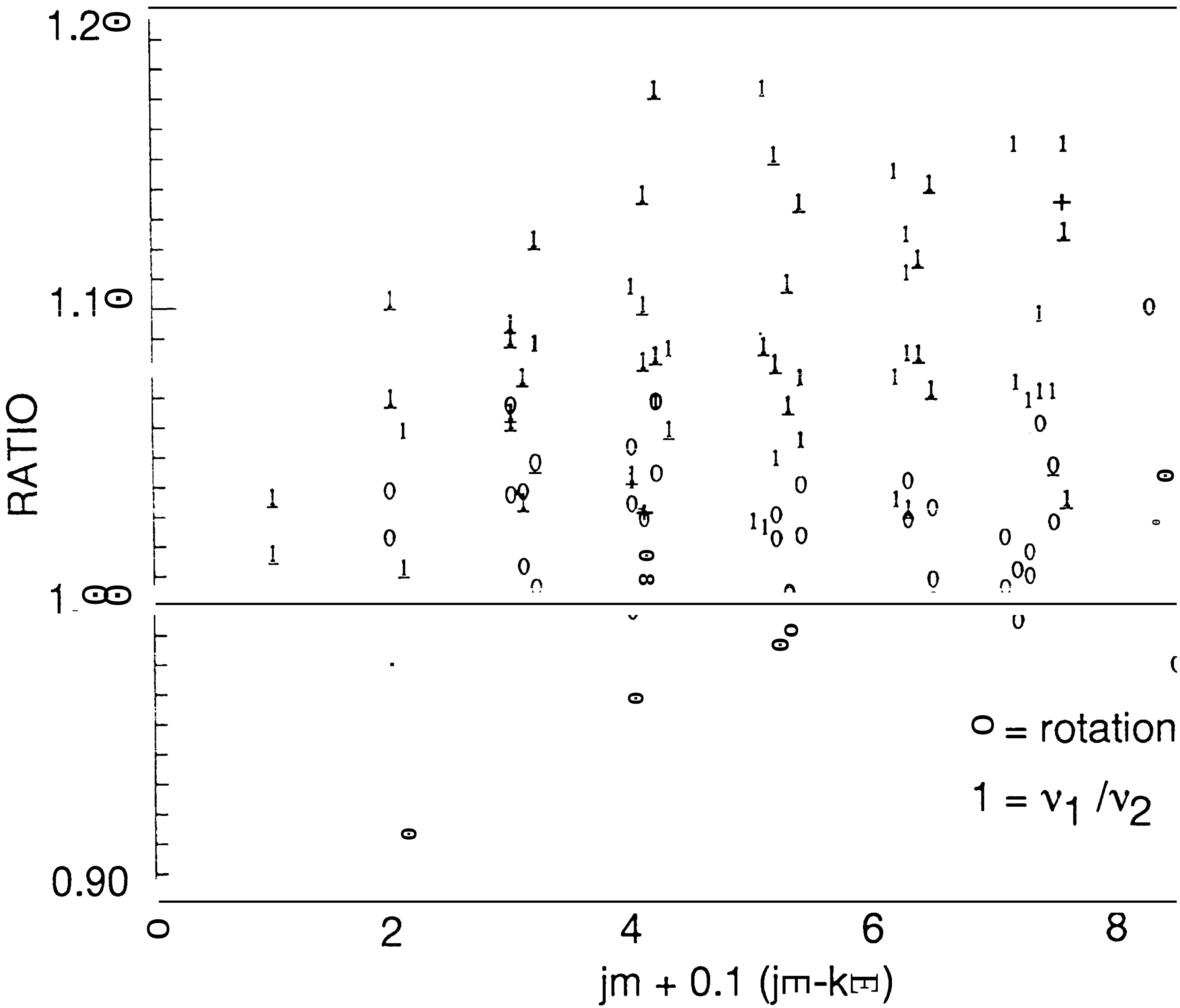


Fig. 7