

H<sub>2</sub>-Broadened H<sub>2</sub><sup>16</sup>O in Four Infrared Bands between 55 and 4045 cm<sup>-1</sup>

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## Abstract

To support the remote sensing of the outer planets, absorption spectra of  $\text{H}_2\text{O}$  broadened by  $\text{H}_2$  were recorded at room temperature using two Fourier transform spectrometers. The data from 1260 to 2070  $\text{cm}^{-1}$  and 3420 to 4045  $\text{cm}^{-1}$  were obtained at 0.0056 and 0.012  $\text{cm}^{-1}$  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  $\text{cm}^{-1}$  was taken at 0.0056  $\text{cm}^{-1}$  with the **HR120 Bruker** FTS at the Jet Propulsion Laboratory. Some 630 Hz-broadened linewidths of  $\text{H}_2^{16}\text{O}$  were obtained with precision of 2% to 7% for the four strongest water bands: rotational at  $\nu_1$   $\text{cm}^{-1}$ ;  $\nu_2$  at 1595  $\text{cm}^{-1}$ ;  $\nu_1$  at 3657  $\text{cm}^{-1}$  and  $\nu_3$  at 3756  $\text{cm}^{-1}$ . The intensity of the weakest measured transition was 0.0065  $\text{cm}^{-2}/\text{atm}$  at room temperature. Within a band, the widths varied from 0.101  $\text{cm}^{-1}/\text{atm}$  to 0.033  $\text{cm}^{-1}/\text{atm}$  at room temperature for  $0 \leq J \leq 12$  and  $0 \leq K_a \leq 6$ . Systematic patterns were detected in the widths as a function of  $AJ$ ,  $J$ ,  $K_a$ , and asymmetry. At low  $K_a$ , the widths decreased with increasing  $J$ , but for  $K_a > 2$ , the widths generally increased with increasing  $J$ . Examination of the vibrational dependencies of the three perpendicular bands also revealed that the widths of the  $\nu_2$  and rotational transitions were nearly the same (within 3%), but the widths of  $\nu_1$  were generally larger (up to 18%). The limited width measurements reported by others in the pure rotational and 1.4  $\mu\text{m}$  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<sup>1</sup> in 1969 and Kasauga et al.<sup>2</sup> in 1978 and the studies over a range of temperatures for the two transitions at 183 and 380 GHz by Dutta et al.<sup>3</sup> in 1993 and eleven transitions at 1.4  $\mu\text{m}$  by Langlois et al.<sup>4</sup> in 1994. Three rotational transitions of hydrogen-broadened HDO near 230 GHz were also measured by Goyette et al.<sup>5</sup> The rotational transitions of H<sub>2</sub>O were 'R<sub>2</sub>' for J'' = 2, 3 and 5, and their observed broadening coefficients were all close to 0.08 cm<sup>-1</sup>/atm at room temperature while the 1.4  $\mu\text{m}$  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<sup>-1</sup>/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  $\nu_2$  band in the important 5  $\mu\text{m}$  window region. Widths were also obtained for the rotational region and the other fundamentals so that vibrational dependence of widths could be investigated. In a continuing effort, Gamache is pursuing theoretical modeling of the line widths<sup>7</sup>.

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<sub>2</sub> and H<sub>2</sub>O. **Figure 1** shows a compressed plot of the  $\nu_2$  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<sub>2</sub>**). 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  $\mu\text{m}$  region and 1 Torr for the 6  $\mu$  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<sub>3</sub>** and **H<sub>2</sub>** in which the water appeared as an impurity inside the absorption cell,<sup>8</sup> 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<sub>2</sub><sup>16</sup>O** could be measured. Only widths of lines with intensities greater than 0.0065 cm<sup>2</sup>/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<sup>9</sup>. The initial calculated positions, intensities and self-broadened widths were taken from the 1992 HITRAN database<sup>10</sup>, 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<sub>2</sub>O 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<sup>10</sup> so that the effective partial pressures of H<sub>2</sub>O could be determined (see **Table 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<sup>10</sup> by more than 15%. **Table 2** summarizes the resulting measurements by giving the vibrational band and its band center in cm<sup>-1</sup>, the number of transitions measured, maximum values of the J and Ka quantum numbers and the effective temperatures in each region,

Other studies<sup>8,11</sup> done with the JPL Bruker and Kitt Peak spectrometers produced

line widths that were clearly precise to  $\pm 3910$  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  $\text{cm}^{-1}$  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 ( $\pm 3\%$ ). The fact that the two sets of widths were done at an  $8^\circ$  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.<sup>3</sup> study observed a temperature dependence coefficient of  $n = 0.95$  and  $0.85$  for two transitions, and Langlois et al.<sup>4</sup> 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  $\text{cm}^{-1}$  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<sup>11</sup> with the Kitt Peak FTS produced values that were within 1% to 4% of results obtained by Ballard et al.<sup>12</sup> with a Bomem FTS, it is expected that an ideal theoretical model will reproduce the bulk of the present  $\text{H}_2$ - $\text{H}_2\text{O}$  coefficients to 4% or better.

## Results and Discussion

In Table 3, some 630  $\text{H}_2$ -broadened linewidths (H WIM) of  $\text{H}_2\text{O}$  and the %rms

agreement are shown along with the calculated positions<sup>10</sup>, 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  $\nu_2$  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 0 --> 3 corresponding respectively to the rotational,  $\nu_1$ ,  $\nu_2$ , and  $\nu_3$  bands. All but 45 of the widths are for allowed transitions with  $\Delta K_a = 0$  or  $\pm 1$ .

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<sup>11</sup>. For example, the widths of P 8 and R 7 are similar because these transitions involve the same rotational quantum numbers; P 8 is  $J'' = 8 \rightarrow J' = 7$  and R 7 is  $J'' = 7 \rightarrow J' = 8$ . In the same way, water transitions are predicted to have same widths<sup>7,10</sup> if they involve the same rotational pairs of (J, Ka, Kc); the width of (7,3,4)  $\rightarrow$  (8,3,5) is expected to be similar to the width of (8,3,5)  $\rightarrow$  (7,3,4). To test this assumption in the present data, the ratios of 79 pairs of widths in the parallel  $\nu_1$  band and the perpendicular band  $\nu_3$  were computed and plotted in Fig. 3 as a function of the maximum J in the transition. The average ratio of these is  $0.9977 \pm 3.4\%$ , 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  $\text{cm}^{-1}/\text{atm}$ . 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  $\nu_2$  and  $\nu_3$  displayed as a function of  $jm$ . The symbol “O” is used for the transition in which  $Ka + Kc - J = 0$  in both the upper and lower states. The symbol “I” 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  $\nu_2$  band and the R and P branch lines of the parallel  $\nu_3$  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  $\nu_3$  Q branch transitions fall midway between the widths of the asymmetry pairs because the Q



type lines arise between the  $K_a + K_c - J = 0$  and  $K_a + K_c - J = 1$  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  $\nu_1$  P and R lines (top) and  $\nu_2$  Q branch lines (bottom) for which  $K_a + K_c - J = 0$  in both the upper and lower states. The plot symbols are the values of  $k_m$ , and curves are drawn to connect widths of the same  $k_m$ . While not all the points lie on smooth curves, some patterns are apparent. For  $k_m = 0$  and 1, the widths drop sharply with increasing  $j_m$ . For  $k_m = 2$ , widths are still decreasing, but for  $k_m = 3$ , the widths both increase and decrease with increasing  $j_m$ . For  $k_m = 4$  and 5 in  $\nu_3$ , the widths increase faster with increasing  $j_m$ . One finds similar trends are seen in the other groupings of transitions ( $1 \rightarrow 1$ ,  $0 \rightarrow 1$ ). While it has been helpful to organize the widths in this manner, it is emphasized that  $j_m$  and  $k_m$  are not true quantum numbers. The widths of the same  $j_m$ ,  $k_m$  do have different values depending on the transition selection rules. Attempts to model these data with empirical expansions in  $j_m$  and  $k_m$  (of the type used or suggested in other studies<sup>8,13</sup>) 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  $J$ ,  $K_a$ .

In a recent review of all existing water linewidths, Gamache et al.<sup>14</sup> 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,  $\nu_2$  and  $\nu_1$ ). For a composite comparison, the ratios of the widths for transitions with exactly the same rotational quanta are computed with the widths of  $\nu_2$  in the denominator. The ratios of the pairs are 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  $\nu_1/\nu_2$  transitions, the widths of the  $\nu_1$  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  $5 \mu\text{m}$  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**<sup>1,4</sup> and present measurements of  **$H_2$ -broadened  $H_2O$**  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<sup>3</sup> 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  $\nu_1$  / rotational widths is less conclusive because the two prior measurements<sup>1,2</sup> disagree by so much. In **Table 5**, the eleven measurements of **Langlois et**

al.<sup>4</sup> for  $\nu_1 + \nu_3$  and  $2\nu_1$  are listed with the corresponding measurements of  $\nu_1$ ,  $\nu_2$  and  $\nu_3$  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  $\text{cm}^{-1} / \text{atm}$  at the temperature shown. Langlois et al. also reported experimental values for the temperature dependence of the  $1.4 \mu\text{m}$  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 ( $\nu_2$  or  $\nu_3$ ). For the paired transitions, the average of the two widths is used for the ratio. All but one of the  $1.4 \mu\text{m}$  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  $\nu_2$  widths at  $6 \mu\text{m}$  have the smallest value and  $2\nu_1$  at  $1.4 \mu\text{m}$  the largest. Thus, the  $1.4 \mu\text{m}$  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.<sup>14</sup> 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<sup>10</sup> 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<sup>14</sup> 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<sup>15</sup>. Thus, the vibrational dependencies must be further investigated for N<sub>2</sub>- and O<sub>2</sub>-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<sub>2</sub>- broadened widths is now available for the four strongest vibrational bands of H<sub>2</sub>O. The experimental precision are demonstrated to be from 2 to 7% by the rns 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  $\nu_2$  and the rotational region are almost the same, but the widths of  $\nu_1$  band are generally larger by as much as 18%. Comparison with eleven widths at 1.4  $\mu\text{m}$  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  $\text{H}_2$  - broadened  $\text{H}_2\text{O}$ .

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## TABLE TITLES

Table 1 Experimental conditions

Table 2 Distribution of the measured Hz-broadened  $\text{H}_2\text{O}$  widths

Table 3 Observed Hz-broadened widths of  $\text{H}_2^{16}\text{O}$  in Four Bands

Table 4 Comparison with the pure rotational width measurements

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

### footnote for Table 2

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

### footnote for Table 3

<sup>+</sup> Positions and intensities are in units of  $\text{cm}^{-1}$  and  $\text{cm}^{-2}/\text{atm}$  at 296 K respectively.  
The Hz-broadened widths are in units of  $\text{cm}^{-1}/\text{atm}$  at the effective temperatures ascribed by the vibrational identification: 0 = rotational region at 295 K, 1 =  $\nu_1$  at 291 K, 2 =  $\nu_2$  at 299 K and 3 =  $\nu_3$  at 291 K.

### footnote for Tables 4 and 5

<sup>+</sup> The  $\text{H}_2$ -broadened widths are in units of  $\text{cm}^{-1}/\text{atm}$  at the given temperature.



Table 1

## EXPERIMENTAL CONDITIONS

Bandpass:	600-2700 $\text{cm}^{-1}$	1800-5200 $\text{cm}^{-1}$	0.0-350 $\text{cm}^{-1}$
Instrument:	Kitt Peak FTS	Kitt Peak FTS	Bruker FTS at JPL
Resolution:	0.0056 $\text{cm}^{-1}$	0.012 $\text{cm}^{-1}$	0.0056 $\text{cm}^{-1}$
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 <sub>2</sub> H <sub>2</sub> O	H <sub>2</sub> H <sub>2</sub> O	H <sub>2</sub> H <sub>2</sub> O
			85 0.35 at 297K
			147 0.09 at 294K
			388 0.10 at 294K
	355 0.51 at 299K	390 0.81 at 292K	
	400 0.20 at 300K	400 2.22 at 290K	
	447 0.52 at 299K	466 0.50 at 292K	
	513 0.37 at 299K	500 2.29 at 290K	
	558 0.77 at 299K	512 1.05 at 291K	584 0.25 at 298K
	764 2.12 at 300K		748 0.18 at 294K
	993 2.20 at 300K		938 0.17 at 295K

Table 2 DISTRIBUTION OF THE MEASURED H,- BROADENED H<sub>2</sub>O WIDTHS

<u>Band</u>	<u>cm<sup>-1</sup></u>	<u>#Widths</u>	<u>Region cm<sup>-1</sup></u>	<u>Maximum J.Ka</u>	<u>Sample Temperatures</u>
Rot.	0.	64	55 - 328	9,6	295 ± 2 K
v <sub>2</sub>	1595.	273	1260 - 2041	12,6	299 ± 1 K
v <sub>1</sub>	3657.	103	3420 - 3975	10,5	291 ± 1 K
v <sub>3</sub>	3756.	<u>190</u>	3480 - 4045	11,5	291 ± 1 K
		total 630			

+ v<sub>2</sub> widths obtained from more than 7 spectra are at an effective temperature of ≈ 295 K.

Table 3 Observed H<sub>2</sub>-Broadened Widths of H<sub>2</sub><sup>16</sup>O in Four Bands\*

Position	Item	$\lambda_{unc}$	width	$\lambda_{unc}$	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	0.9	5	
3709.4016	1.65+0	(0.9)	0.0865	(0.7)	3	1 0 1	2 0 2 0	. 9 8	5	
3600.65	2.18-1	(1.4)	0.0901	(1.0)	1	1 0 1	2 1 2 0	. 9 5	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	. 9 5	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	. 9 4	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	(0.5)	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	. 9 6	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	. 9 3	4	
55.7021	1.10+1	(2.3)	0.0854	(0.8)	0	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	. 9 8	5	
3598.1346	1.87-1	(0.9)	0.0832	(0.4)	1	2 1 2	3 0 3 0	. 9 5	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)	0	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)	0	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	. 9 8	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)	0	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	. 9 3	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)	0.0214	(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)	0.0835	(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)	0	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
3726.4475	4.03-2 (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)	.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)	0	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)	0	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)	0	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)	0.0737 (2.4)	1	3	2	2	4	3	1	0.94	5
150.5182	5.96+1 (2.4)	0.0663 (3.7)	0	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)	0	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)	0	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)	0	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)	0	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
3843.74% 9.95-1 (1.3)	0.0728 (1.1)	3	4	2	3	3	2	2	0.9	8
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)	0	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)	0	4	3	1	4	2	2	0.9	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)	0	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)	0	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)	0	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)	0	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)	0	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	0.9	2
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	0.9	4
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	0.9	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	1.0	4
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	0.9	5
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)	0.0650 (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	1.0	4

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)	0	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	0.9	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)	0	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)	0	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
3725.6845	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)	0	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)	0.0537	(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	2	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	2	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	(1	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	5	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	2	7	0.%	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	0.9%	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	1.02	7			
3934.0995	9.77-2	(1.7)	0.0472	(1.2)	3	9	1	8	8	1	7	0.9%	5			
193.4811	5.97+0	(5.4)	0.0432	(3.6)	0	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	2	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	0.9%	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
3480.39361	1.36-2	(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	2	11	11	1	10	1.08	7			

† Positions and intensities are in units of  $\text{cm}^{-1}$  and  $\text{cm}^{-2}/\text{atm}$  at 296 K respectively.

The  $t_{1/2}$ -broadened widths are in units of  $\text{cm}^{-1}/\text{atm}$  at the effective temperatures ascribed by the vibrational identification: O = rotational region at 295 K, 1 =  $\nu_1$  at 291 K, 2 =  $\nu_2$  at 299 K and 3 =  $\nu_3$  at 291 K.

Table 4

Comparison with pure rotational width measurements

Study	$J' K_a' K_c'$	$J'' K_a'' K_c''$	Band	Observed $y$	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	$\nu_1$	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	$\nu_1$	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  $\text{cm}^{-1} / \text{atm}$

Table 5

Comparison with the 1.4  $\mu\text{m}$  width measurements

J' K <sub>a</sub> K <sub>c</sub>	J'' K <sub>a</sub> K <sub>c</sub>	Band	$\gamma$ (%unc) Obs. _____	Temp K	Ratio y higher vib / y 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	$\nu_3$	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	$\nu_3$	0.0943 (0.8)	291	
2 1 1	- 2 1 2	$\nu_3$	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	$\nu_3$	0.0750 (1.3)	291	
3 2 1	- 3 2 2	$\nu_3$	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	$\nu_3$	0.0602 (2.2)	291	
4 3 2	- 4 3 1	$\nu_1 + \nu_3$	0.0700 (2.9)	300	1 . 1 2
4 3 1	- 4 3 2	$\nu_1 + \nu_3$	0.0640 (3.1)	300	
4 3 1	- 4 3 2	$\nu_3$	0.0632 (0.4)	291	
4 3 2	- 4 3 1	$\nu_3$	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	$\nu_1$	0.0794 (3.1)	291	1.02
3 1 2	- 3 2 1	$\nu_1$	0.0832 (1.1)	291	
3 2 1	- 3 1 2	$\nu_2$	0.0803 (0.8)	299	
3 1 2	- 3 2 1	$\nu_2$	0.0806 (1.1)	299	
4 2 2	- 4 1 3	$2\nu_1$	0.1230 (8.1)	300	
4 1 3	- 4 2 2	$\nu_1$	0.0824 (4.3)	291	1.09
4 2 2	- 4 1 3	$\nu_2$	0.0762 (1.1)	299	1.06
4 1 3	- 4 2 4	$\nu_2$	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	$\nu_1$	0.0762 (2.4)	291	1.06
5 1 4	- 5 2 3	$\nu_1$	0.0767 (1.8)	291	
5 2 3	- 5 1 4	$\nu_2$	0.0717 (0.4)	299	
5 1 4	- 5 2 3	$\nu_2$	0.0721 (0.7)	299	

## FIGURE CAPTIONS

Fig. 1 The spectrum of Hz-broadened  $\text{H}_2\text{O}$  in the  $\nu_2$  region recorded at  $0.0056 \text{ cm}^{-1}$  resolution with Kitt Peak FTS. The optical path is 1.5 m. The pressures of  $\text{H}_2\text{O}$  and  $\text{H}_2$  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  $\text{H}_2\text{-H}_2\text{O}$  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  $\nu_1$  and 3 for  $\nu_3$ .

Fig. 4 Composite of all observed widths in  $\text{cm}^{-1}/\text{atm}$  at room temperature as a function of km (maximum  $K_a$ ) 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. 5 The variation of the  $km = 2$  widths as a function of jm with the value of  $K_a + K_c - J = 0$  or 1 as the plot symbol. These are widths of transitions for which the upper and lower state levels are both either  $K_a + K_c - J = 0$  or 1, as 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  $\nu_3$  band

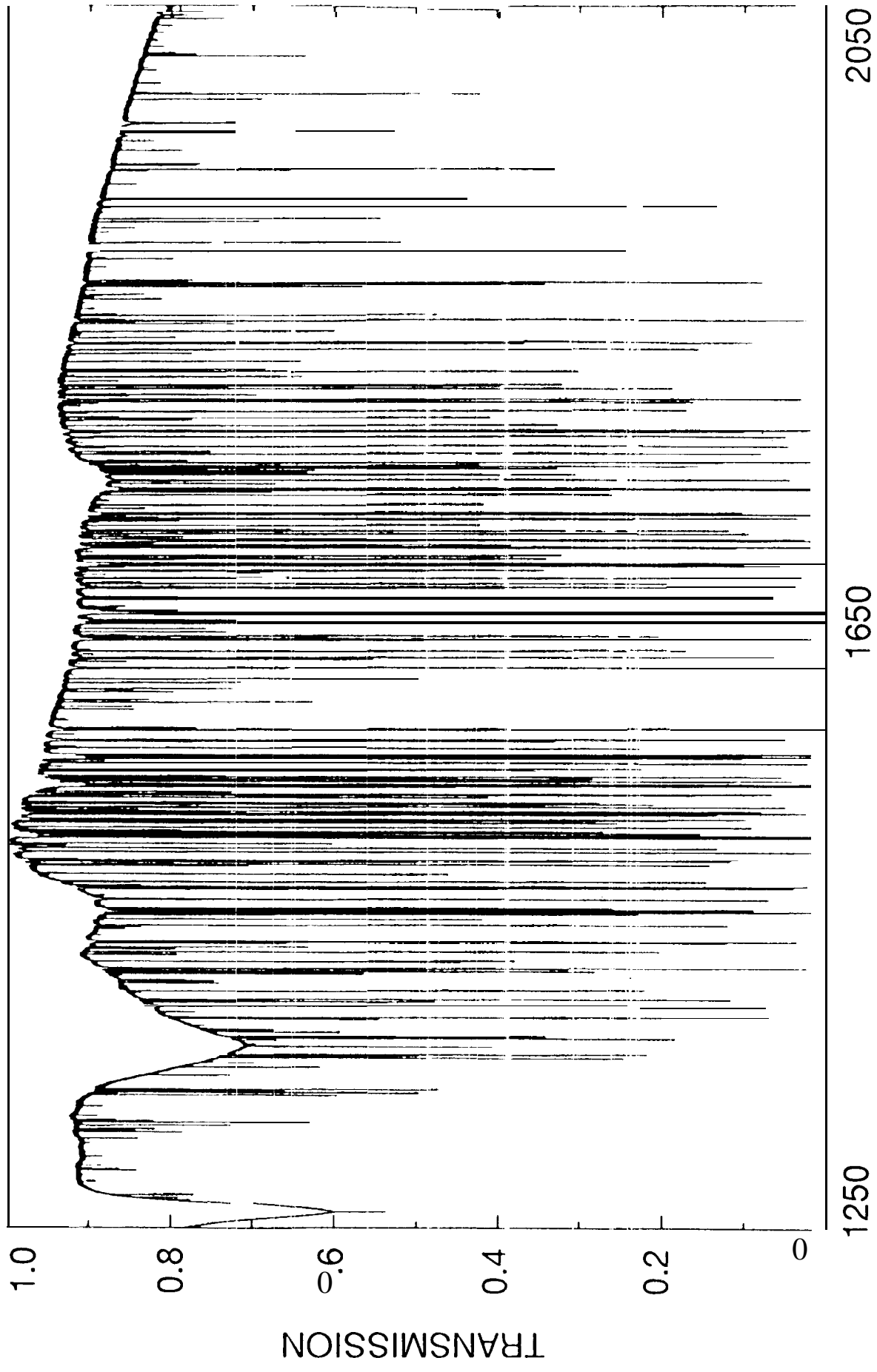
BOTTOM: Q branch transitions of the perpendicular  $\nu_2$  band.

Fig. 6 The variation of the widths for  $K_a + K_c - J = ()$  transitions for all km (maximum  $K_a$ ) as a function of jm (maximum J). The plot symbols are km where  $km = K_a''$  for  $\Delta K_a = -1$  and 0 or  $km = K_a + 1$  for  $\Delta K_a = +1$ .

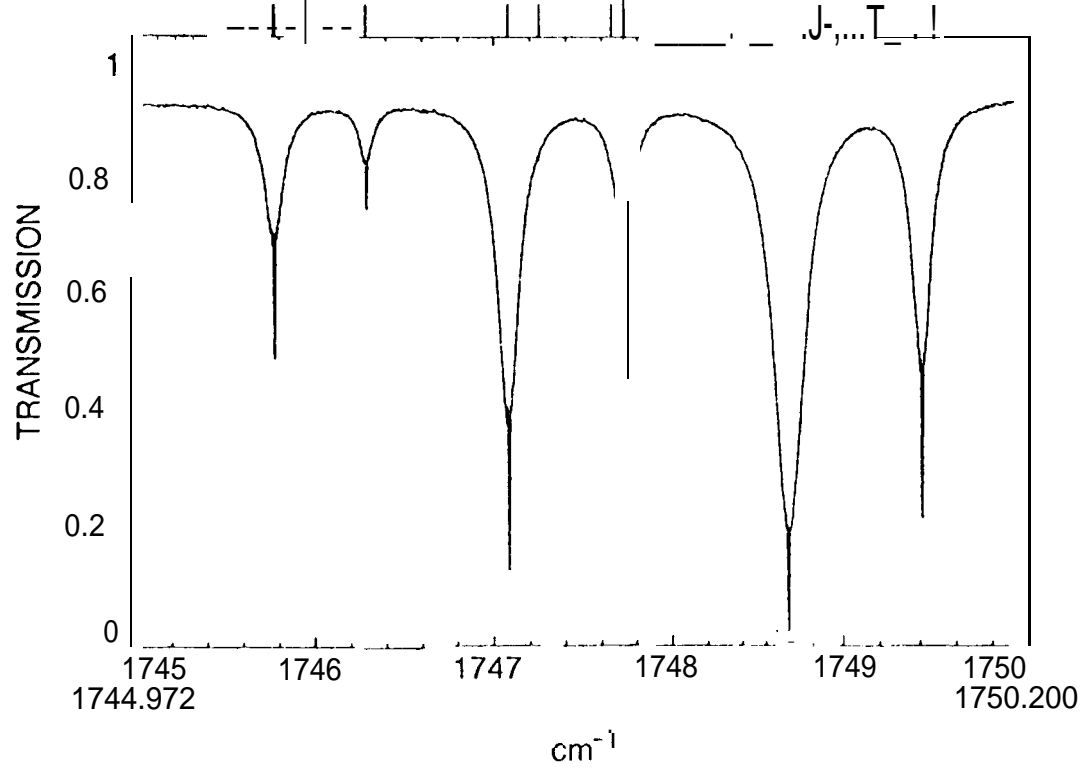
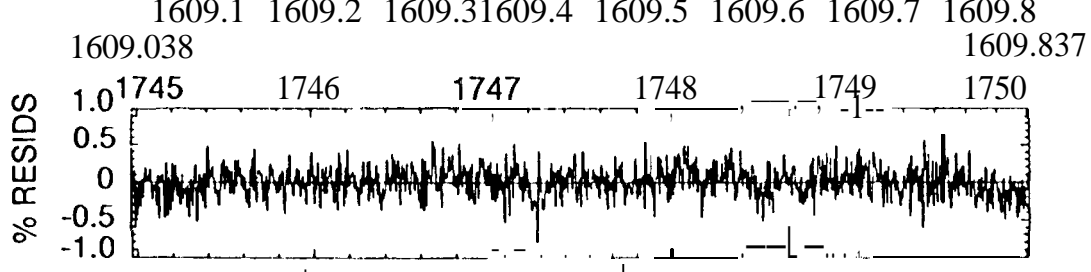
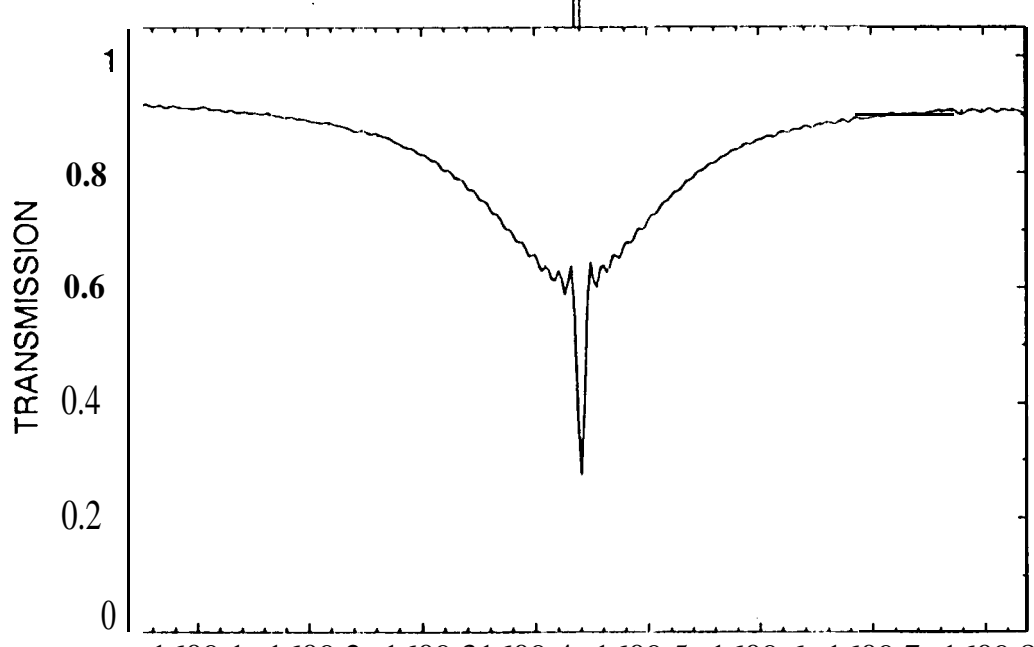
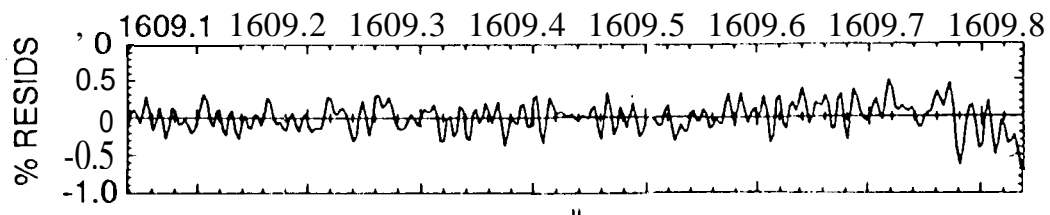
TOP: R and P branch transitions of the parallel  $\nu_3$  band

BOTTOM: Q branch transitions of the perpendicular  $\nu_2$  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  $\nu_2$  are the denominator. The plot symbols 0 and 1 indicate, respectively, that the rotational or  $\nu_1$  widths were used for the numerator. The average ratio of rotational to  $\nu_2$  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  $\nu_1$  to  $\nu_2$  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



cm<sup>-1</sup>



