Transition frequencies and absolute strengths of $H_2{}^{17}O$ and $H_2{}^{18}O$ in the 6.2-μm region

Robert A. Toth

Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California 91109

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High-resolution spectra of oxygen-enriched samples of water vapor were recorded with a Fourier-transform spectrometer covering transitions in the (010)–(000) bands. The measured line frequencies were used along with measurements taken from studies at microwave and far-infrared frequencies to obtain rotational energy levels in the (000) and (010) states of $H_2{}^{17}O$ and $H_2{}^{18}O$. Measurements of the line strengths were fitted to a model in which as many as 18 transition moment parameters were determined. The results produced computed line-strength values that are in excellent agreement with the 623 $H_2{}^{17}O$ experimental transition strengths and 696 $H_2{}^{18}O$ values. These results provide a more accurate representation of the line positions and strengths for the (010)–(000) bands of $H_2{}^{17}O$ and $H_2{}^{18}O$ than those previously available.

INTRODUCTION

This study involves high-resolution measurements of line positions and absolute strengths in the (010)–(000) bands of $H_2{}^{17}O$ and $H_2{}^{18}O$ covering the 1000–2225-cm^{-1} region. This task complements my recent study[1] of the (010)–(000) band of $H_2{}^{16}O$.

Previous laboratory frequency measurements of $H_2{}^{17}O$ and $H_2{}^{18}O$ in the 6.2-μm spectral region include the studies by Guelachvili,[2] Williamson *et al.*,[3] and Camy-Peyret *et al.*[4] Guelachvili[2] recorded high-spectral-resolution data for natural water-vapor samples with a Fourier-transform spectrometer (FTS) and reported measurements of transition frequencies in the (010)–(000) bands of $H_2{}^{16}O$, $H_2{}^{17}O$, and $H_2{}^{18}O$. Williamson *et al.*[3] obtained 0.04-cm^{-1}-resolution spectra of $H_2{}^{18}O$-enriched samples and determined the rotational energy levels in the (000) and (010) vibrational states from the line-frequency measurements. Spectra of natural water-vapor samples for the region between 1800 and 2200 cm^{-1} were observed with a FTS by Camy-Peyret *et al.*,[4] and the data were analyzed to determine the vibration–rotation parameters of a Watson-type Hamiltonian[5] for the (010)–(000) bands of $H_2{}^{17}O$ and $H_2{}^{18}O$.

There have not been any reports in the literature of $H_2{}^{17}O$ and $H_2{}^{18}O$ line-strength measurements in the (010)–(000) bands, although values for these parameters are given in the 1986 edition of the HITRAN database[6]; these values, in turn, were taken from a tabulation by Flaud *et al.*,[7] which presents an atlas of $H_2{}^{16}O$, $H_2{}^{17}O$, and $H_2{}^{18}O$ line positions and strengths between 0 and 4350 cm^{-1}. The line-strength calculations for the (010)–(000) bands were based on $H_2{}^{16}O$ measurements, and the $H_2{}^{17}O$ and the $H_2{}^{18}O$ values were inferred from the $H_2{}^{16}O$ results.

In the present investigation values of the line-center positions measured in this study were used in conjunction with far-IR measurements between 33 and 280 cm^{-1} ($H_2{}^{18}O$) by Johns[8] and between 50 and 730 cm^{-1} ($H_2{}^{17}O$ and $H_2{}^{18}O$) by Kauppinen and Kyro[9] and with microwave measurements obtained by DeLucia *et al.*[10] ($H_2{}^{17}O$), Steenbeckeliers and Bellet[11] ($H_2{}^{17}O$ and $H_2{}^{18}O$), and DeLucia *et al.*[12] ($H_2{}^{18}O$) to obtain values of the ground-state energy levels for these two species. Energy levels in the (010) state were determined from the (010)–(000) band measurements and the ground-state levels. The experimental line strengths were analyzed by the method I used in the analysis of $H_2{}^{16}O$ data.[1] Briefly, the method is based on the theory developed by Flaud and Camy-Peyret,[13] in which the original 8 elements[13] of the dipole moment expansion are used along with 11 additional terms in a least-squares analysis of the measured line strengths. The initial eight elements were found to be adequate when only the stronger transitions were considered; however, inclusion of the weaker line strengths required additional terms in the theory.

EXPERIMENTAL DETAILS

The spectra were obtained with a FTS located at the McMath solar telescope facility at the Kitt Peak National Observatory. The experimental conditions and extent of the measurements are given in Table 1. All data were obtained with an absorption path of 2.39 m, and the sample temperatures were 297 K. The $H_2{}^{17}O$ and $H_2{}^{18}O$ samples were purchased from Merck and Company, Inc.; the stated isotopic purities were 98.1% $H_2{}^{18}O$ for one sample and 60.4% $H_2{}^{17}O$ for the other. The first set of spectra was for the O^{18}-enriched sample, as is noted in the table. The experiments using the $H_2{}^{17}O$ sample followed the $H_2{}^{18}O$ runs, and it was determined from an analysis of the spectra that the gas sample of the initial $H_2{}^{17}O$ run (0.31 Torr of total pressure) contained less $H_2{}^{17}O$ (percent relative abundance of 42.9% $H_2{}^{17}O$) than the manufacturer's stated purity of 60.4%. The spectra of the following two runs showed increases in the $H_2{}^{17}O$ relative abundances of the samples (52.1% and 59.9%), whereas the $H_2{}^{18}O$ relative content in these samples showed decreases. The decreases indicated that a small residue of $H_2{}^{18}O$ molecules remained in the absorption cell even after the absorption cell was pumped, purged with N_2, and evacuated again, which was the procedure followed before the

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Table 1. Experimental Conditions of Spectra Used in the $H_2{}^{17}O$ and $H_2{}^{18}O$ Measurements[a]

Range of Measurements (cm^{-1})	Unapodized Spectral Resolution (cm^{-1})	Total Sample Pressure (Torr)	% Abundance of Isotopic Species				
			$H_2{}^{16}O$	$H_2{}^{17}O$	$H_2{}^{18}O$	$HD{}^{18}O$	$HD{}^{17}O$
1170–2149	0.0056	0.25	ND	0.62	98.1	1.2	ND
1061–2192	0.0056	0.65	ND	0.62	98.1	1.2	ND
1009–2192	0.0056	1.41	ND	0.62	98.1	1.2	ND
1009–2299	0.0056	4.99	ND	0.62	98.1	1.2	ND
1170–2129	0.0056	0.31	ND	42.9	35.8	ND	0.2
1102–2198	0.0056	1.33	ND	52.1	30.7	ND	0.2
1061–2224	0.0056	5.21	ND	59.9	27.3	ND	0.2

[a]Absorption path length for all spectral runs was 2.39 m, and sample temperatures were 297 K. ND, not determined.

$H_2{}^{17}O$ study began. Further checks of the $H_2{}^{18}O$ and the $H_2{}^{17}O$ relative abundances in the samples were determined from the spectra and from the $H_2{}^{17}O$ and the $H_2{}^{18}O$ spectral absorptions observed in the $H_2{}^{16}O$ spectra used in the earlier report.[1] The $H_2{}^{16}O$ samples used in that study[1] contained normal isotopic amounts of $H_2{}^{17}O$ (0.036%) and $H_2{}^{18}O$ (0.204%). By these procedures the uncertainties in the $H_2{}^{18}O$ amounts in the $H_2{}^{18}O$ samples (first four entries in Table 1) were estimated to be slightly less than 1%, whereas the $H_2{}^{17}O$ and the $H_2{}^{18}O$ relative amounts in the $H_2{}^{17}O$ samples (last three entries in Table 1) were estimated to be uncertain by approximately 2% and 1%, respectively.

As is noted in Table 1, the impurities in the $H_2{}^{18}O$ sample were found to be $H_2{}^{17}O$ (0.62%) and $HD{}^{18}O$ (1.2%), whereas impurities observed in the spectra of the $H_2{}^{17}O$ samples were $H_2{}^{18}O$ and $HD{}^{17}O$ (0.2%). The HDO impurities were not noted by the manufacturer, and their presence was determined from an analysis of additional spectra; one gas sample contained enriched $HD{}^{18}O$ (created from a mixture of D_2O and $H_2{}^{18}O$), and another sample contained $HD{}^{17}O$. The $H_2{}^{16}O$ contents in the $H_2{}^{17}O$ and $H_2{}^{18}O$ samples were not determined, mainly because of the difficulty in separating, for a given observed $H_2{}^{16}O$ line, the contribution resulting from the low-pressure $H_2{}^{16}O$ content in the vacuum tank that enclosed the FTS from that in the O_2-enriched samples. A comparison of the $H_2{}^{16}O$ absorptions observed in the runs noted in the table with that taken of the evacuated cell indicated that the $H_2{}^{16}O$ amount in any of the runs listed in Table 1 was less than 0.5% in relative abundance.

The $H_2{}^{17}O$ and the $H_2{}^{18}O$ liquid samples obtained from the distributor were contained in sealed and evacuated glass tubes. Contamination of the samples by the atmosphere was minimized in the transfer of the evaporated isotopic species from the container to the 2.39-m-long cell by employing a special glass envelope. The apparatus consisted of a sleeve that contained the sealed liquid sample and a glass arm in which a movable metal piece was situated. The sealed apparatus was pumped for an hour or more, and, when the monitored pressure was extremely low, the metal piece was moved toward the sealed tube; if necessary, the procedure was repeated until the sealed tube containing the sample broke. Soon after the contents were allowed to evaporate into the apparatus, the pumping action was cut off, and the O_2-enriched water vapor was allowed to flow into the absorption cell. Two identical apparatuses were constructed; one was used for the $H_2{}^{18}O$ experiment and the other for the $H_2{}^{17}O$-enriched sample.

The IR source was a Globar, and the radiation traveled through short open spaces and the absorption cell before entering the vacuum tank. Atmospheric contributions were minimized by purging the open spaces with cooled N_2 gas. A He-cooled, As-doped Si detector collected the IR radiation, and each spectral run consisted of at least eight superimposed interferograms. The composite interferograms were transformed into spectral data at the Kitt Peak facility. During the 50-min or longer observation period for each FTS run, the gas sample pressure and temperature were monitored continuously. Total sample pressures were measured with a Baratron gauge, and the sample temperatures were inferred from readings of two thermistor probes in thermal contact with the absorption cell walls. The estimated uncertainties in the measured pressures and temperatures were 0.5% and 1.0 K, respectively.

Two computer programs were used to measure the spectra. These were used in the analysis of $H_2{}^{16}O$ spectra[1] and were described in an earlier report.[14] Briefly, one program, labeled LINEFINDER, determines line-center positions and relative absorption peaks; the other program uses the technique of nonlinear least-squares, in which absorption line positions, strengths, linewidths, and continuum parameters are fitted simultaneously in an interactive mode on the computer. The measured line positions obtained by either technique were calibrated and corrected by reference to known $H_2{}^{16}O$ calibration frequencies[1] as calibration standards. The observed $H_2{}^{16}O$ lines resulted mainly from the low-pressure (200-μm total pressure) $H_2{}^{16}O$ content in the vacuum tank and the slight, if any, $H_2{}^{16}O$ impurity in the O_2-enriched samples in the absorption cell.

ENERGY LEVELS

The same technique[1] used to determine values of the rotational energy levels in the (000) and (010) vibrational states of $H_2{}^{16}O$ was used here to obtain term values for the states of $H_2{}^{17}O$ and $H_2{}^{18}O$. The concept employs combination difference frequencies (CDF's) in the ground state determined from measurements in the (010)–(000) band plus additional measurements obtained in the (020)–(000), (100)–(000), and (001)–(000) bands, used in conjunction with microwave measurements[10-12] and $H_2{}^{18}O$ far-IR measurements[8] to determine values of the ground-state rota-

Table 2. Rotational Energy Levels of the (000) and (010) Vibrational States of $H_2{}^{17}O$ and $H_2{}^{18}O^a$

			(000)				(010)						
J	K_a	K_c	$H_2{}^{17}O$		$H_2{}^{18}O$		$H_2{}^{17}O$		$H_2{}^{18}O$		J	K_a	K_c
0	0	0	0.00000		0.00000		1591.32565	5	1588.27567	10	0	0	0
1	0	1	23.77351	2	23.754902	0.5	1615.11512	2	1612.04601	2	1	0	1
1	1	1	36.93111	2	36.748647	0.5	1631.31501	3	1628.06006	3	1	1	1
1	1	0	42.18694	2	42.023428	0.5	1636.87274	2	1633.63471	3	1	1	0
2	0	2	70.00467	2	69.927440	0.5	1661.45949	4	1658.33390	3	2	0	2
2	1	2	79.22734	2	78.988654	0.5	1673.34734	2	1670.03711	3	2	1	2
2	1	1	94.97054	2	94.788645	0.5	1689.99276	2	1686.73337	3	2	1	1
2	2	1	134.14527	3	133.475798	0.7	1738.02754	2	1734.21852	3	2	2	1
2	2	0	135.43118	2	134.783115	0.7	1739.22848	3	1735.43774	3	2	2	0
3	0	3	136.53762	2	136.336669	0.7	1728.26026	2	1725.01689	4	3	0	3
3	1	3	141.90241	2	141.568060	0.7	1735.66575	2	1732.26277	2	3	1	3
3	1	2	173.11009	2	172.882910	0.7	1768.70419	2	1765.39801	3	3	1	2
3	2	2	205.48182	2	204.755913	0.7	1809.44407	2	1805.57671	2	3	2	2
3	2	1	211.43578	1	210.799282	0.7	1815.07905	3	1811.29062	4	3	2	1
3	3	1	283.56166	3	282.09458	3	1902.15935	2	1897.45282	2	3	3	1
3	3	0	283.76776	3	282.30709	3	1902.32895	2	1897.62724	2	3	3	0
4	0	4	221.62081	2	221.23401	1	1813.61195	4	1810.18732	2	4	0	4
4	1	4	224.30423	1	223.828555	0.7	1817.62639	4	1814.08716	4	4	1	4
4	1	3	275.13055	2	274.80321	2	1871.65496	4	1868.25385	3	4	1	3
4	2	3	299.43892	2	298.62018	1	1903.56907	3	1899.60894	2	4	2	3
4	2	2	315.07849	1	314.45946	1	1918.65776	3	1914.88091	2	4	2	2
4	3	2	380.80593	4	379.29162	4	1999.46329	2	1994.70331	5	4	3	2
4	3	1	382.17599	4	380.70252	3	2000.59878	2	1995.87013	2	4	3	1
4	4	1	485.20903	2	482.64357	2	2122.93237	5	2117.00849	4	4	4	1
4	4	0	485.23684	2	482.67262	2	2122.95273	6	2117.02971	2	4	4	0
5	0	5	324.66099	2	324.04675	3	1916.67358	4	1913.02264	3	5	0	5
5	1	5	325.88023	3	325.21574	1	1918.65488	3	1914.93352	2	5	1	5
5	1	4	398.87940	2	398.36052	3	1996.85377	5	1993.27689	5	5	1	4
5	2	4	415.12802	2	414.16819	2	2019.55169	3	2015.45396	3	5	2	4
5	2	3	445.79344	2	445.15858	4	2049.71212	4	2045.92267	2	5	2	3
5	3	3	502.17968	2	500.59627	1	2120.97240	7	2116.13858	2	5	3	3
5	3	2	507.17439	2	505.72884	2	2125.17883	3	2120.45465	2	5	3	2
5	4	2	607.15929	2	604.54422	3	2244.95965	6	2238.97495	2	5	4	2
5	4	1	607.39740	2	604.79294	3	2245.13452	6	2239.15705	4	5	4	1
5	5	1	737.62061	9	733.67939	2	2397.77881	5	2390.35358	4	5	5	1
5	5	0	737.62415	9	733.68310	7	2397.78115	3	2390.35608	3	5	5	0
6	0	6	445.71922	5	444.84623	2	2037.39776	4	2033.48870	3	6	0	6
6	1	6	446.24496	2	445.34623	1	2038.32509	5	2034.37691	6	6	1	6
6	1	5	541.99683	3	541.18017	3	2141.94454	4	2138.08859	2	6	1	5
6	2	5	551.60938	2	550.45085	2	2156.47142	3	2152.18212	2	6	2	5
6	2	4	601.96080	7	601.23786	1	2206.85500	3	2202.99275	3	6	2	4
6	3	4	647.07220	2	645.38263	3	2266.15787	2	2261.21753	2	6	3	4
6	3	3	659.98679	3	658.61010	3	2277.32399	6	2272.64614	2	6	3	3
6	4	3	753.70510	2	751.03301	2	2391.56739	3	2385.51357	3	6	4	3
6	4	2	754.81181	8	752.18752	3	2392.38680	7	2386.36587	3	6	4	2
6	5	2	884.07779	9	880.07636	4	2544.40996	5	2536.90967	2	6	5	2
6	5	1	884.11390	6	880.11463	3	2544.43388	10	2536.93489	4	6	5	1
6	6	1	1038.76539	15	1033.19414	6	2723.62232	10	2714.44436	9	6	6	1
6	6	0	1038.76595	30	1033.19456	8	2723.62280	40	2714.44446	10	6	6	0
7	0	7	584.94089	3	583.77780	2	2175.93741	5	2171.74074	3	7	0	7
7	1	7	585.16194	2	583.98653	2	2176.36028	4	2172.14324	1	7	1	7
7	1	6	702.88597	3	701.69433	3	2304.99914	3	2300.77427	4	7	1	6
7	2	6	708.01636	3	706.59783	2	2313.44576	2	2308.90606	4	7	2	6
7	2	5	781.37727	2	780.45286	2	2388.07275	4	2384.04199	3	7	2	5

Table 2. *Continued*

			(000)				(010)						
J	K_a	K_c	$H_2{}^{17}O$		$H_2{}^{18}O$		$H_2{}^{17}O$		$H_2{}^{18}O$		*J*	K_a	K_c
7	3	5	814.61075	3	812.76176	3	2434.22907	2	2429.13504	3	7	3	5
7	3	4	840.86487	5	839.54954	2	2457.67610	3	2453.05763	2	7	3	4
7	4	4	924.64153	6	921.89590	2	2562.59955	2	2556.46217	4	7	4	4
7	4	3	928.29587	3	925.69983	3	2565.34541	5	2559.31399	2	7	4	3
7	5	3	1055.05411	7	1050.99030	3	2715.50255	3	2707.92173	3	7	5	3
7	5	2	1055.25530	6	1051.20326	3	2715.63588	8	2708.06223	2	7	5	2
7	6	2	1209.81339	4	1204.16951	4	2894.98645	10	2885.71721	5	7	6	2
7	6	1	1209.81842	9	1204.17496	2	2894.98966	6	2885.72063	10	7	6	1
7	7	1	1386.41873	20	1378.98643	14	3097.34225	45	3086.18826	13	7	7	1
7	7	0	1386.41898	9	1378.98643	14	3097.34225	45	3086.18826	13	7	7	0
8	0	8	742.39857	4	740.91235	3	2332.40026	10	2327.88508	5	8	0	8
8	1	8	742.49085	5	740.99874	3	2332.59152	3	2328.06602	4	8	1	8
8	1	7	881.09903	4	879.49487	3	2485.15129	4	2480.50570	6	8	1	7
8	2	7	883.65191	2	881.91415	6	2489.72633	3	2484.87728	3	8	2	7
8	2	6	981.49596	4	980.22238	3	2590.96402	7	2586.63359	3	8	2	6
8	3	6	1003.78133	3	1001.70586	2	2624.22928	3	2618.92134	3	8	3	6
8	3	5	1048.65714	4	1047.32865	5	2665.60912	4	2661.00404	4	8	3	5
8	4	5	1119.48803	4	1116.63623	2	2757.66597	3	2751.41854	5	8	4	5
8	4	4	1128.93814	3	1126.43916	2	2764.94432	3	2758.96016	7	8	4	4
8	5	4	1250.49869	6	1246.36865	4	2910.99637	9	2903.32966	4	8	5	4
8	5	3	1251.29115	4	1247.20616	5	2911.52516	7	2903.88643	3	8	5	3
8	6	3	1405.14811	16	1399.42806	4	3090.56812	7	3081.20101	4	8	6	3
8	6	2	1405.18093	4	1399.46336	4	3090.58788	10	3081.22207	10	8	6	2
8	7	2	1582.19624	16	1574.67826	25	3293.60285	15	3282.34196	20	8	7	2
8	7	1	1582.19672	16	1574.67845	35	3293.60356	10	3282.34264	24	8	7	1
8	8	1	1778.30779	25	1768.80155	30	3515.93481	20	3502.60781	20	8	8	1
8	8	0	1778.30779	25	1768.80155	30	3515.93481	20	3502.60781	20	8	8	0
9	0	9	918.10200	2	916.25779	3	2506.82584	4	2501.95936	4	9	0	9
9	1	9	918.14050	8	916.29360	5	2506.91246	15	2502.04083	3	9	1	9
9	1	8	1076.80099	3	1074.76308	4	2682.37533	3	2677.28341	3	9	1	8
9	2	8	1078.02032	8	1075.90952	4	2684.74692	4	2679.53359	3	9	2	8
9	2	7	1199.96295	3	1198.19966	2	2813.05657	7	2808.28028	6	9	2	7
9	3	7	1213.56231	4	1211.18576	3	2835.15251	4	2829.56108	2	9	3	7
9	3	6	1281.26845	6	1279.79767	3	2899.39855	9	2894.70566	3	9	3	6
9	4	6	1337.48949	3	1334.47935	4	2976.12209	3	2969.72202	4	9	4	6
9	4	5	1357.55585	8	1355.19927	4	2992.13633	8	2986.25913	12	9	4	5
9	5	5	1470.22554	5	1466.01837	14	3130.73149	4	3122.96952	6	9	5	5
9	5	4	1472.68499	9	1468.61221	8	3132.39268	6	3124.71649	7	9	5	4
9	6	4	1624.69354	6	1618.89634	7	3310.25716	4	3300.78708	8	9	6	4
9	6	3	1624.84233	12	1619.05594	7	3310.34699	9	3300.88304	3	9	6	3
9	7	3	1801.98494	16	1794.37475	12	3513.80024	18	3502.42271	10	9	7	3
9	7	2	1801.99017	9	1794.38045	8	3513.80312	10	3502.42598	10	9	7	2
9	8	2	1998.95625	19	1989.35202	80	3737.25325	30	3723.80404	12	9	8	2
9	8	1	1998.95635	19	1989.35202	80	3737.25325	30	3723.80404	12	9	8	1
9	9	1	2212.16617	300	2200.40535	25	3976.58649	25	3960.90895	35	9	9	1
9	9	0	2212.16617	300	2200.40535	25	3976.58649	25	3960.90895	35	9	9	0
10	0	10	1112.02499	10	1109.78708	4	2699.20781	4	2693.95614	5	10	0	10
10	1	10	1112.04116	5	1109.80211	3	2699.24745	4	2693.99338	4	10	1	10
10	1	9	1290.22818	6	1287.73485	3	2896.91783	15	2891.35977	3	10	1	9
10	2	9	1290.79853	3	1288.26735	2	2898.11899	4	2892.49216	2	10	2	9
10	2	8	1435.36731	8	1433.02899	2	3052.43092	4	3047.09238	4	10	2	8
10	3	8	1443.04107	4	1440.28806	5	3066.05164	3	3060.10398	3	10	3	8
10	3	7	1536.15667	6	1534.36837	5	3156.73632	6	3151.80973	8	10	3	7
10	4	7	1577.68835	5	1574.44957	4	3217.11097	11	3210.49931	6	10	4	7
10	4	6	1613.90094	7	1611.65357	8	3247.24322	16	3241.48623	5	10	4	6
10	5	6	1713.84955	10	1709.54026	11	3374.39338	8	3366.51786	2	10	5	6
10	5	5	1720.18418	12	1716.19991	10	3378.75881	4	3371.09897	10	10	5	5
10	6	5	1868.33073	12	1862.45488	5	3553.91092	10	3544.33442	5	10	6	5
10	6	4	1868.85882	9	1863.02021	15	3554.23163	11	3544.67620	5	10	6	4
10	7	4	2045.63885	12	2037.93405	5	3757.74618	8	3746.24537	3	10	7	4
10	7	3	2045.66456	7	2037.96225	18	3757.76049	15	3746.26098	15	10	7	3

(continued overleaf)

Table 2. *Continued*

			(000)				(010)						
J	K_a	K_c	$H_2{}^{17}O$		$H_2{}^{18}O$		$H_2{}^{17}O$		$H_2{}^{18}O$		J	K_a	K_c
10	8	3	2243.31375	45	2233.60323	30	3982.19397	40	3968.60945	40	10	8	3
10	8	2	2243.31440	80	2233.60362	30	3982.19397	40	3968.61025	40	10	8	2
10	9	2	2457.83590	50	2445.95550	25	4223.11065	40	4208.52029	20	10	9	2
10	9	1	2457.83590	50	2445.95550	25	4223.11065	40	4208.52029	20	10	9	1
10	10	1	2685.84239	90	2671.62985	100					10	10	1
10	10	0	2685.84239	90	2671.62985	100					10	10	0
11	0	11	1324.12157	8	1321.45434	8	2909.51494	2	2903.84380	5	11	0	11
11	1	11	1324.12830	20	1321.46052	5	2909.53331	6	2903.86091	3	11	1	11
11	1	10	1521.51755	9	1518.54258	5	3128.98788	6	3122.94139	5	11	1	10
11	2	10	1521.78224	6	1518.78799	4	3129.59052	13	3123.50601	9	11	2	10
11	2	9	1687.38292	5	1684.43944	4	3308.19035	10	3302.22939	4	11	2	9
11	3	9	1691.48503	12	1688.28644	5	3316.11966	7	3309.74527	12	11	3	9
11	3	8	1810.66703	8	1808.36235	7	3435.06637	10	3429.72577	3	11	3	8
11	4	8	1839.03757	10	1835.48680	20	3479.64817	20	3472.75155	8	11	4	8
11	4	7	1896.45521	8	1894.19587	6	3529.44342	10	3523.74050	5	11	4	7
11	5	7	1980.75352	18	1976.29723	11	3641.47384	40	3633.45155	8	11	5	7
11	5	6	1994.66386	7	1990.85690	5	3651.36020	8	3643.79532	8	11	5	6
11	6	6	2135.85851	10	2129.89782	10	3821.33008	40	3811.64162	10	11	6	6
11	6	5	2137.41991	10	2131.56620	15	3822.28735	40	3812.68000	300	11	6	5
11	7	5	2312.99648	90	2305.19585	45	4025.23810	50	4013.61061	40	11	7	5
11	7	4	2313.09838	54	2305.30636	10	4025.29633	40	4013.67143	15	11	7	4
11	8	4	2511.16195	50	2501.45280	80	4250.85300	300	4236.76675	40	11	8	4
11	8	3	2511.16608	25	2501.45732	20	4250.85555	60	4236.76895	40	11	8	3
11	9	3	2726.85000	300							11	9	3
11	9	2	2726.85010	300							11	9	2
12	0	12	1554.33465	5	1551.20212	4	3137.70051	4	3131.57518	6	12	0	12
12	1	12	1554.33768	5	1551.20496	8	3137.70941	4	3131.58339	3	12	1	12
12	1	11	1770.71182	11	1767.22511	12	3378.69726	6	3372.13552	5	12	1	11
12	2	11	1770.83503	7	1767.33865	6	3378.99964	3	3372.41739	3	12	2	11
12	2	10	1956.23550	8	1952.67815	30	3580.27923	35	3573.67560	15	12	2	10
12	3	10	1958.35833	13	1954.65356	10	3584.72620	8	3577.86090	3	12	3	10
12	3	9	2102.55395	25	2099.56255	10	3731.75210	40	3725.96590	40	12	3	9
12	4	9	2120.51612	17	2116.56486	4	3762.72165	6	3755.45790	12	12	4	9
12	4	8	2202.89734	90	2200.43699	300	3836.95240	50	3831.07000	300	12	4	8
12	5	8	2270.10752	14	2265.43837	10	3931.26571	25	3923.04649	15	12	5	8
12	5	7	2296.59750	100	2293.01000	85	3950.91300	300	3943.49850	40	12	5	7
12	6	7	2426.94740	300	2420.88520	25	4112.22326	50			12	6	7
12	6	6	2430.92450	300	2425.12391	300					12	6	6
13	0	13	1802.59895	6	1798.96549	7	3383.70953	8	3377.09551	5	13	0	13
13	1	13	1802.60001	6	1798.96637	7	3383.71324	19	3377.09926	4	13	1	13
13	1	12	2037.79639	5	2033.76570	4	3646.08238	5	3638.97577	11	13	1	12
13	2	12	2037.85408	10	2033.81822	5	3646.23492	5	3639.11705	8	13	2	12
13	2	11	2242.21211	6	2238.03206	10	3868.96959	5	3861.71641	7	13	2	11
13	3	11	2243.29282	50	2239.02987	35	3871.41260	20	3864.00033	10	13	3	11
13	3	10	2410.54103	300	2406.76989	13	4045.34602	40	4038.65473	8	13	3	10
13	4	10	2421.16090	90	2416.78403	40			4057.66655	40	13	4	10
13	4	9	2530.58221	300	2527.68887	90					13	4	9
13	5	9			2575.97123	300					13	5	9
13	5	8			2622.01033	40					13	5	8
14	0	14	2068.84310	80	2064.67225	80	3647.48050	40	3640.34227	40	14	0	14
14	1	14	2068.84365	80	2064.67291	20	3647.48100	40	3640.34344	12	14	1	14
14	1	13	2322.71550	200	2318.11367	20	3931.13348	40	3923.44902	40	14	1	13
14	2	13	2322.74833	7	2318.13820	35	3931.21109	40	3923.52195	15	14	2	13
14	2	12	2545.51450	300	2540.65963	40			4166.66191	300	14	2	12
14	3	12	2545.88172	10	2541.17262	40			4167.85026	15	14	3	12
14	3	11			2729.76880	300			4366.48340	300	14	3	11
14	4	11							4378.55929	40	14	4	11
15	0	15	2352.98827	50	2348.24648	25	3928.94380	50	3921.24790	25	15	0	15
15	1	15	2352.98860	100	2348.24651	40	3928.94380	50	3921.24810	25	15	1	15
15	1	14	2625.41069	300			4233.81173	40	4225.51964	15	15	1	14
15	2	14	2625.41889	500			4233.84680	50	4225.55707	40	15	2	14
15	2	13							4488.52332	40	15	2	13
16	0	16	2654.94766	300	2649.60481	90	4228.02847	40	4219.74131	20	16	0	16
16	1	16	2654.94779	300	2649.60481	90	4228.02847	40	4219.74131	20	16	1	16
17	0	17					4544.65299	50	4535.74571	40	17	0	17
17	1	17					4544.65299	50	4535.74571	40	17	1	17

[a] Values are in inverse centimeters, and estimated uncertainties are in inverse centimeters times 10^5.

tional energies. The additional measurements obtained in the 2.7-μm region (2850–4300 cm^{-1}) are not reported here.

Initially, CDF's and pure rotational frequencies with quantum numbers involving $J \leq 6$ were fitted by using the Hamiltonian of Watson,[5] including terms of K^n with $n \leq 10$. The accurate term values for the lowest ($J < 4$) energy levels obtained in this way were then used as a starting point to determine values of the higher J, K_a, and K_c levels by adding the determined value of the lower rotational level to the CDF's and pure rotational frequencies. These results were weighted and averaged, with the highest weight given to the values obtained from the microwave measurements.

After the ground-state values and associated estimated uncertainties were obtained, the rotational energy levels in the (010) state were derived by adding the appropriate lower-state energy level to each measured transition frequency of the (010)–(000) band. These results were weighted and then averaged for each level.

Table 2 lists values of the rotational energy levels and associated uncertainties obtained in this study for the (000) and (010) states of $H_2{}^{17}O$ and $H_2{}^{18}O$. The uncertainties given for the ground-state levels are estimates of absolute uncertainties, whereas, for the excited-state levels, the uncertainties relate to the precision of the measurements, as is noted in Ref. 1.

It was also pointed out in the $H_2{}^{16}O$ report[1] that a least-squares fit of all of the CDF and pure rotational measurements to the Hamiltonian did not fit with residuals that were within the overall accuracy of the measurements, especially for values with $J > 12$. The same result is seen in the present study for both isotopic species. However, as is further noted in Ref. 1, the parameters obtained from the fits were of high enough accuracy to permit adequate computation of the matrix elements of the direction cosines that are involved in the analysis of the line strengths. The vibration–rotation parameters obtained from these fits for the (000) states of $H_2{}^{17}O$ and $H_2{}^{18}O$ are given in Table 3, along with values of these parameters for the (010) states derived by Camy-Peyret *et al.*[4] The application of these values to the line-strength analysis is discussed below.

LINE STRENGTHS

The strength S of a H_2O transition at frequency ν may be expressed to good approximation by

$$S = C(\nu/Q)(g/T)[1 - \exp(-\nu/kT)] \times \exp[-E(L)/kT]|R(L,U)|^2, \tag{1a}$$

where

$$C = 8\pi^3/3hc,$$
$$Q = Q_V \times Q_R,$$
$$E(L) = E_V(L) + E_R(L), \tag{1b}$$

where Q is the partition function, which can be expressed as the product of the vibrational, Q_V, and the rotational, Q_R, partition functions; g is the degeneracy caused by the nuclear spin of the lower state level; k is the Boltzmann constant; T is the temperature; $E(L)$ is the lower-state energy, which is equal to the sum of the lower-state vibrational energy $E_V(L)$ and the rotational energy $E_R(L)$; and $R(L,U)$ is the vibration–rotation dipole moment matrix element connecting the lower state L with the upper state U. When T = 296 K, Q_R = 175.5 and Q_R = 176.1 for $H_2{}^{17}O$ and $H_2{}^{18}O$, respectively, and Q_V = 1.0004 for

Table 3. Vibration–Rotation Energy Level Parameters of the (000) and (010) States of $H_2{}^{17}O$ and $H_2{}^{18}O$

	$H_2{}^{17}O$		$H_2{}^{18}O$	
Parameter	(000)	(010)[a]	(000)	(010)[a]
A	27.6954551	30.9195	27.531288	30.7311
B	14.5213409	14.68579	14.5218844	14.68445
C	9.2570365	9.10918	9.2380179	9.09099
Δ_K	3.2104569×10^{-2}	5.727×10^{-2}	3.1698583×10^{-2}	5.650×10^{-2}
Δ_{JK}	-5.693317×10^{-3}	-7.543×10^{-3}	-5.704319×10^{-3}	-7.476×10^{-3}
Δ_J	1.232580×10^{-3}	1.3894×10^{-3}	1.2507967×10^{-3}	1.3882×10^{-3}
H_K	1.224641×10^{-4}	3.70×10^{-4}	1.27559×10^{-4}	3.67×10^{-4}
H_{KJ}	$-8.0301625 \times 10^{-6}$	-4.310×10^{-5}	-2.23195×10^{-5}	-4.65×10^{-5}
H_{JK}		3.410×10^{-6}		4.80×10^{-6}
H_J	-1.12328×10^{-6}	5.45×10^{-7}	3.84932×10^{-7}	5.62×10^{-7}
L_K	-9.71486×10^{-8}	-2.44×10^{-6}	-6.45387×10^{-7}	-2.445×10^{-6}
L_{KKJ}	-7.5812×10^{-7}		1.5086×10^{-8}	
L_J	3.50756×10^{-8}		3.3233×10^{-9}	
P_K	6.4657×10^{-9}	1.0594×10^{-8}	3.22513×10^{-9}	1.0594×10^{-8}
δ_K	1.088133×10^{-3}	3.639×10^{-3}	1.28393×10^{-3}	3.634×10^{-3}
δ_J	4.93109×10^{-4}	5.780×10^{-4}	5.09357×10^{-4}	5.784×10^{-4}
h_K	1.67287×10^{-5}	7.94×10^{-5}	3.05251×10^{-5}	7.76×10^{-5}
h_{JK}	-2.05715×10^{-5}		-2.68263×10^{-7}	1.02×10^{-6}
h_J	3.5230×10^{-7}	2.83×10^{-7}	2.89792×10^{-7}	2.82×10^{-7}
l_K	-7.56917×10^{-7}	-2.88×10^{-7}		-1.93×10^{-7}
l_{KJ}	1.735×10^{-6}			

[a] Parameters taken from Ref. 4.

Table 4. Matrix Elements Used in the Expansion of the Dipole Moment for *B*-Type Transitions of Water Vapor[a]

j	n	$\langle JK\|A'(j)\|J'K'\rangle / \langle JK\|\Phi(x)\|J'K+\Delta K\rangle$, $\Delta K = \pm 1$
2	1	$J'(J'+1) + J(J+1)$
3	1	$K'^2 + K^2$
4	1	$K'^2 - K^2$
5	1	$K'^2 - K^2 - 2m$
6	1	$(K'^2 - K^2)(K'^2 - K^2 - 2m)$
7	1	$J(J+1) - 2m(m-1) + (2m-1)K\Delta K - K^2 - 1$
8	3	$[(J' - K\Delta K - 1)(J' - K\Delta K - 2)(J' + K\Delta K + 2)(J' + K\Delta K + 3)]^{1/2}$
9	1	$K'^2 J'(J'+1) - K^2 J(J+1)$
10	1	$K'^4 - K^4$
11	1	$(K'^2 - K^2)[J'(J'+1) + J(J+1)]$
12	1	$K'^2(J'^2 + J')^2$
13	1	K'^6
14	1	K'^4
15	1	$K'^2 J'(J'+1)$
16	1	$K'^6 - K^6$
17	1	$J'(J'+1)$ if $m = 0$ and $J = K_c$ or $J' = K_c'$; otherwise 0
18	1	$J'(J'+1)$ if $m = 0$ and $J = K_c$ or $J' = K_c' - 1$; otherwise 0
19	1	$J'(J'+1)$ if $m \neq 0$ and $J = K_c$ or $J' = K_c'$; otherwise 0

[a]Matrix elements for $j = 2$ to $j = 8$ are taken from Ref. 13. $J' - J = 0, \pm 1$; $m = [J'(J'+1) - J(J+1)]/2$; $K' - K = n\Delta K$.

Table 5. Dipole Moment Expansion Coefficients Derived from Least-Squares Fits of $H_2{}^{17}O$ and $H_2{}^{18}O$ Measured Lines Strengths in the (010)–(000) Bands (values in debeyes)[a]

	$H_2{}^{17}O$		$H_2{}^{18}O$	
	Spectral Coverage (cm^{-1})		Spectral Coverage (cm^{-1})	
j	1087–1699	1701–2198	1009–1699	1700–2219
1	0.1311(5)	0.1286(10)	0.1299(5)	0.1287(7)
2	$1.29(27) \times 10^{-5}$	$1.45(47) \times 10^{-5}$	$3.83(27) \times 10^{-5}$	$9.24(483) \times 10^{-6}$
3	$2.77(651) \times 10^{-5}$	$-1.94(87) \times 10^{-4}$	$-6.32(556) \times 10^{-5}$	$-1.96(106) \times 10^{-4}$
4	$-6.43(12) \times 10^{-3}$	$-5.99(29) \times 10^{-3}$	$-6.32(9) \times 10^{-3}$	$-6.04(32) \times 10^{-3}$
5	$-3.09(20) \times 10^{-4}$	$-3.44(87) \times 10^{-4}$	$-4.59(17) \times 10^{-4}$	$-2.98(62) \times 10^{-4}$
6	$-2.61(70) \times 10^{-5}$	$-8.5(122) \times 10^{-6}$	$-3.38(75) \times 10^{-5}$	$3.0(153) \times 10^{-7}$
7	$6.67(22) \times 10^{-5}$	$3.22(124) \times 10^{-5}$	$7.21(24) \times 10^{-5}$	$1.55(137) \times 10^{-5}$
8	$-5.06(15) \times 10^{-5}$	$-1.55(20) \times 10^{-5}$	$-5.91(14) \times 10^{-5}$	$-2.14(13) \times 10^{-5}$
9	$-1.23(23) \times 10^{-5}$	$-1.16(351) \times 10^{-6}$	$-1.54(21) \times 10^{-5}$	$8.7(464) \times 10^{-7}$
10	$1.42(22) \times 10^{-5}$	$1.25(12) \times 10^{-5}$	$1.82(15) \times 10^{-5}$	$1.16(80) \times 10^{-5}$
11	$2.81(115) \times 10^{-6}$	$5.1(134) \times 10^{-7}$	$5.17(80) \times 10^{-6}$	$1.80(129) \times 10^{-6}$
12	$5.39(101) \times 10^{-8}$	$3.74(678) \times 10^{-9}$	$1.74(67) \times 10^{-8}$	$1.65(393) \times 10^{-9}$
13	$1.39(38) \times 10^{-7}$	$-2.77(277) \times 10^{-8}$	$2.93(173) \times 10^{-8}$	$-2.65(781) \times 10^{-8}$
14	$-2.17(275) \times 10^{-6}$	$4.34(312) \times 10^{-6}$	$5.25(159) \times 10^{-6}$	$4.24(515) \times 10^{-6}$
15	$-7.93(168) \times 10^{-6}$	$-1.14(128) \times 10^{-6}$	$-4.35(108) \times 10^{-6}$	$-1.87(84) \times 10^{-6}$
16	$1.25(30) \times 10^{-7}$		$6.86(193) \times 10^{-8}$	$1.10(116) \times 10^{-8}$
17	$2.63(62) \times 10^{-5}$		$-6.45(98) \times 10^{-5}$	$-2.86(180) \times 10^{-5}$
18			$-3.84(59) \times 10^{-5}$	$-1.63(92) \times 10^{-5}$
N[b]	359	264	415	281
$\sigma\%$[c]	4.5	4.4	4.6	4.1

[a]Values given within parentheses are uncertainties in the last digit(s).
[b]N represent the number of line strengths used in the least-squares fit.
[c]$\sigma\%$ is the standard deviation resulting from the least-squares fit in percent: $\sigma\% = 100\{\Sigma[(S_{obs} - S_{cal})/S_{obs}]^2/N\}^{1/2}$.

both species, and for temperatures within 30 K of 300 K $Q(T) = Q(296\ \mathrm{K})(296/T)^{3/2}$.

Without consideration of near-resonance effects, the vibration–rotation dipole moment element $R(L,U)$, given in Eq. (1), can be expressed as

$$R(L,U) = \sum_j u(j)x(j)$$
$$x(j) = \langle V'', J'', K_a'', K_c''|A(j)|V', J', K_a', K_c'\rangle, \qquad (2)$$

where $u(j)$ are the dipole moment coefficients, $A(j)$ are the transformed transition moment operators, and primes and double primes denote upper and lower states, respectively. $x(1)$ is the matrix element of the direction cosines in which $A(1) = \Phi_\alpha$ with $\alpha = z$ for *A*-type transitions and $\alpha = x$ for *B*-type transitions. The asymmetric top wave functions, $AS(V, J, K_a, K_c)$, are expressed as an expansion of the symmetry-adapted wave functions, $s(J, K, \gamma)$, as

$$AS(V, J, K_a, K_c) = \Psi_v C(J, K_a, K_c | J, K, \gamma) s(J, K, \gamma), \quad (3)$$

where the C's are coefficients of the wave functions; thus the lower- and the upper-state wave functions are expressed in terms of symmetry-adapted rotational wave functions.

The matrix elements involved in $R(L,U)$ and used in this study are given in Table 4. The elements $j = 2$ to

Table 6. Line Positions (cm^{-1}) and Strengths (cm^{-2}/atm at 296 K) Observed in the (010)–(000) Band of $H_2{}^{17}O$[a]

Observed Position	o − c	Upper J	Upper K_a	Upper K_c	Lower J	Lower K_a	Lower K_c	Observed Strength	%s	(o − c)%	R
1011.8642	-33	10	1	10	11	2	9	{4.50E-04}			
1063.78473	-4	9	0	9	10	3	8	1.57E-03	15	11.1	1.40
1071.5454	25	9	1	9	10	2	8	4.20E-04	15	-18.3	
1087.45195	-1	10	2	9	11	3	8	6.55E-04	5	-7.2	
1099.2071	8	9	2	7	10	5	6	6.00E-04	10	2.5	
1101.2161	-2	6	2	5	7	5	2	6.01E-04	10	7.0	
1104.68696	-2	9	1	8	10	4	7	1.58E-03	3	-2.5	1.31
1110.0288	-42	6	1	6	7	4	3	8.80E-04	10	8.4	1.20
1118.83766	-29	8	0	8	9	3	7	1.47E-03	3	8.1	1.32
1120.739	52	8	2	6	9	5	5	3.64E-04	15	9.3	
1132.62861	4	8	1	8	9	2	7	4.71E-03	2	1.6	1.31
1137.5737	-36	7	2	5	8	5	4	1.26E-03	2	0.0	1.15
1147.66175	-5	8	1	7	9	4	6	1.35E-03	3	-4.6	1.24
1148.59030	5	9	2	8	10	3	7	8.45E-04	6	-9.3	1.28
1151.8001	-79	6	2	4	7	5	3	3.71E-04	10	-10.1	
1163.8427	-29	5	1	5	6	4	2	5.56E-04	10	4.8	
1165.6341	-23	5	2	3	6	5	2	8.98E-04	6	0.4	1.09
1169.59643	0	10	3	8	11	4	7	1.18E-03	3	-0.4	1.24
1172.15605	-3	7	0	7	8	3	6	1.08E-02	5	0.8	1.25
1185.51110	-1	7	1	6	8	4	5	8.57E-03	4	-1.8	1.19
1194.86428	-4	7	1	7	8	2	6	5.09E-03	4	9.3	1.24
1208.45788	0	8	2	7	9	3	6	1.09E-02	2	1.0	1.20
1210.2288	-19	4	1	4	5	4	1	1.95E-03	4	1.7	1.14
1217.30296	-5	6	1	5	7	4	4	4.13E-03	5	-4.8	1.15
1221.25158	1	9	3	7	10	4	6	1.94E-03	3	4.8	1.16
1222.4471	-1	10	4	7	11	5	6	1.77E-03	3	-3.3	1.14
1222.7869	-11	6	0	6	7	3	5	8.28E-03	3	1.2	1.19
1225.559	161	9	0	9	9	3	6	1.20E-04	15	-41.7	
1236.9735	3	10	5	6	11	6	5	1.45E-03	4	-4.8	1.07
1240.8126	6	10	6	5	11	7	4	8.10E-04	4	-6.9	1.00
1241.2352	5	10	6	4	11	7	5	2.92E-04	10	0.9	
1242.9003	0	10	5	5	11	6	6	4.73E-04	10	-8.1	
1243.14872	5	5	1	4	6	4	3	1.26E-02	3	-3.5	1.12
1246.5801	0	10	7	4	11	8	3	4.35E-04	10	5.6	
1246.5987	16	10	7	3	11	8	4	1.20E-04	10	-13.3	
1250.4282	-71	3	1	3	4	4	0	3.94E-04	5	2.4	
1255.93784	-7	9	4	6	10	5	5	2.50E-03	5	-1.0	1.08
1256.9474	-42	6	1	6	7	2	5	4.08E-02	2	-0.1	1.18
1259.3359	0	11	4	7	12	5	8	4.50E-04	15	-19.0	
1261.8726	-7	9	5	5	10	6	4	1.92E-03	3	3.4	1.02
1264.06191	-4	9	5	4	10	6	5	5.38E-03	3	-3.8	1.01
1264.4954	-27	4	1	3	5	4	2	2.85E-03	5	2.7	1.11
1264.5926	0	9	6	4	10	7	3	1.02E-03	3	-0.1	0.94
1264.7081	-4	9	6	3	10	7	4	3.12E-03	3	1.8	0.94
1264.78861	-1	7	2	6	8	3	5	1.36E-02	4	0.5	1.15
1266.4897	0	10	4	6	11	5	7	7.79E-04	10	7.3	1.08
1266.6733	-13	8	3	6	9	4	5	2.50E-02	3	6.8	1.11
1269.60133	-5	5	0	5	6	3	4	4.49E-02	2	-2.5	1.16
*1270.4890	-37	9	7	2	10	8	3	2.06E-03	4	7.8	0.86
1272.3935	-13	6	2	5	6	5	2	3.09E-04	5	-4.1	
1278.28674	-4	9	4	5	10	5	6	8.13E-03	3	0.1	1.06
*1279.4176	25	9	8	1	10	9	2	8.28E-04	3	3.4	0.77
1283.4950	-16	3	1	2	4	4	1	2.97E-03	3	4.0	1.09
1283.7436	48	8	0	8	8	3	5	3.93E-04	15	22.9	
1284.6197	-29	6	1	6	6	4	3	9.46E-04	5	0.3	0.96
1284.98098	0	8	4	5	9	5	4	2.60E-02	3	-2.6	1.05
1286.15413	9	8	5	4	9	6	3	1.72E-02	2	-5.3	0.98
1286.8316	-2	8	5	3	9	6	4	6.10E-03	3	0.8	0.98
1288.57798	3	8	6	3	9	7	2	9.55E-03	3	-2.3	0.90
1288.6029	-4	8	6	2	9	7	3	3.38E-03	4	3.6	0.90
*1290.7441	0	9	9	0	10	10	1	2.60E-04	15	-24.6	
*1294.4926	-13	14	1	14	15	0	15	9.51E-04	15	16.7	
*1294.6465	0	8	7	2	9	8	1	5.88E-03	4	-2.9	0.81
1294.7188	2	8	4	4	9	5	5	9.25E-03	2	1.3	1.03
1305.29091	-2	7	3	5	8	4	4	2.83E-02	3	1.1	1.08
1310.32162	0	7	5	3	8	6	2	1.75E-02	3	-0.4	0.95
1310.48785	8	7	5	2	8	6	3	4.75E-02	8	-10.4	0.95
1311.30842	2	7	4	4	8	5	3	2.67E-02	3	-1.1	1.02
1311.43231	4	4	0	4	5	3	3	2.19E-02	3	3.2	1.12
1311.4955	-1	5	1	5	5	4	2	3.60E-04	10	-8.0	
1312.7899	17	7	6	2	8	7	1	8.95E-03	5	-4.9	0.87
1312.7937	28	7	6	1	8	7	2	2.69E-02	5	-4.7	0.87
1314.5502	-5	11	3	8	12	4	9	9.65E-04	10	2.2	1.04
1314.84670	-2	7	4	3	8	5	4	7.70E-02	6	-5.9	1.02
*1314.8671	122	13	0	13	14	1	14	2.58E-03	10	-11.8	1.14
1315.60660	5	6	2	5	7	3	4	1.45E-01	6	1.5	1.11
1316.69398	-2	5	1	5	6	2	4	4.09E-02	4	3.2	1.14
1317.6987	-5	10	3	7	11	4	8	1.15E-03	3	4.3	1.04
*1319.03447	1	7	7	0	8	8	1	1.61E-02	4	-8.6	0.78
1321.71018	-2	9	3	6	10	4	7	1.11E-02	4	1.1	1.04
1322.7408	-30	6	2	4	6	5	1	2.42E-04	10	-0.7	
1323.0879	3	13	2	11	14	3	12	2.00E-04	10	3.9	
1323.3340	-5	13	1	12	14	2	13	{6.10E-04}			
1324.8194	-8	9	1	8	9	4	5	1.30E-03	10	8.1	1.00
1328.11969	6	8	3	5	9	4	6	1.17E-02	3	1.9	1.05
1332.4171	-26	4	1	4	4	4	1	7.26E-04	10	1.0	0.99
1332.81743	-2	7	2	5	7	5	2	1.17E-03	10	6.1	0.89
1334.59150	-4	6	5	2	7	6	1	1.40E-01	4	2.2	0.93
1334.62057	8	6	5	1	7	6	2	4.10E-02	5	-10.7	0.93
1335.07246	-8	7	0	7	7	3	4	4.00E-03	3	-5.4	1.05
1335.1005	0	12	0	12	13	1	13	2.50E-03	3	2.0	1.12
1335.11047	1	12	1	12	13	0	13	7.55E-03	3	2.6	1.12
1336.31207	-2	6	4	3	7	5	2	2.25E-01	8	4.7	1.00
*1337.20330	-4	6	6	1	7	7	0	9.20E-02	5	-6.1	0.85
1337.33270	1	6	4	2	7	5	3	7.36E-02	4	2.6	1.00
1337.86198	-2	6	3	4	7	4	3	2.50E-01	5	-0.3	1.05
1338.18809	2	7	3	4	8	4	5	1.05E-01	6	4.2	1.05
1340.3716	2	9	2	7	9	5	4	{7.71E-04}			0.91
1340.8431	-8	12	1	11	13	2	12	7.22E-04	3	0.1	1.09
1341.20325	0	12	2	11	13	1	12	2.30E-03	3	6.1	1.08
1342.5141	1	12	3	10	13	2	11	7.15E-04	10	1.3	1.05
1345.8593	14	13	1	13	13	2	12	6.10E-04	10	7.9	
1345.9131	-4	13	0	13	13	1	12	1.80E-03	5	6.3	1.40
1347.45433	0	3	0	3	4	3	2	5.30E-02	2	-2.3	1.10
1349.8318	-22	11	2	9	12	3	10	2.52E-03	3	3.4	1.03
1352.68247	1	6	3	3	7	4	4	8.30E-02	7	-7.5	1.04
1355.17728	2	11	0	11	12	1	12	2.20E-02	3	-3.3	1.10
1355.1986	-6	11	1	11	12	0	12	8.12E-03	4	6.9	1.10
1356.21315	0	8	1	7	8	4	4	1.33E-03	10	-6.7	0.99
1358.15287	2	11	1	10	12	2	11	7.20E-03	3	1.6	1.05
1358.8788	10	11	2	10	12	1	11	2.40E-03	4	1.7	1.05
*1359.0154	-36	5	5	0	6	6	1	4.23E-01	5	-0.4	0.92
1359.56488	-2	5	2	4	6	3	3	1.51E-01	3	2.1	1.08
1359.88415	-1	11	3	9	12	2	10	7.90E-04	5	-0.6	1.01
1360.84579	4	5	4	2	6	5	1	1.65E-01	3	-1.3	0.99
1360.9458	-9	10	2	8	11	3	9	{2.56E-03}			1.01
1361.0569	17	5	4	1	6	5	2	(5.02E-01}			0.98
1366.16064	5	5	3	3	6	4	2	1.99E-01	5	-4.7	1.04
1366.8744	2	12	1	12	12	2	11	5.52E-03	3	-0.7	1.35
1366.9887	1	12	0	12	12	1	11	1.90E-03	4	2.4	1.34
1370.01554	4	9	2	7	10	3	8	2.21E-02	3	0.4	1.01
1371.47365	-8	5	3	2	6	4	3	6.35E-01	4	-0.5	1.03
1371.83295	0	4	1	4	5	2	3	3.48E-01	5	2.5	1.10
1375.1261	22	10	1	10	11	0	11	5.92E-02	10	-8.0	1.09
1375.13552	-7	10	1	9	11	2	10	6.32E-03	15	-12.3	1.03
1376.60142	-2	10	2	9	11	1	10	2.11E-02	3	-0.4	1.03
1376.7033	3	7	1	6	7	4	3	9.70E-03	5	0.5	0.99
1377.0940	-22	11	4	8	12	3	9	3.00E-04	15	19.3	
1377.40175	4	8	2	6	9	3	7	2.08E-02	5	7.4	1.02
1377.4113	33	6	0	6	6	3	3	4.82E-03	5	-6.0	1.05
1377.89778	-5	2	0	2	3	3	1	7.20E-03	5	3.7	1.08
1378.66873	1	10	3	8	11	2	9	7.26E-03	3	-0.4	0.99
1384.29146	4	7	2	5	8	3	6	1.48E-01	4	4.6	1.03
1385.30822	0	4	4	1	5	5	0	1.04E-00	3	-0.2	0.97
1385.33218	6	4	4	0	5	5	1	3.52E-01	3	1.3	0.97
1386.4180	-12	4	1	3	4	4	0	1.02E-03	10	-2.5	1.00
1387.13262	-11	6	1	5	6	4	2	4.25E-03	3	-0.2	0.99
1387.75111	4	11	1	11	11	2	10	5.71E-03	3	2.4	1.30
1387.99739	0	11	0	11	11	1	10	1.57E-02	3	-6.5	1.30
1389.45639	2	5	1	4	5	4	1	9.49E-03	2	2.1	0.99
1391.57678	-2	9	1	8	10	2	9	5.73E-02	3	-1.1	1.03
1392.06588	-1	4	3	2	5	4	1	1.35E-00	3	1.3	1.03

(continued overleaf)

Table 6. *Continued*

Observed Position	o − c	Upper J	Upper K_a	Upper K_c	Lower J	Lower K_a	Lower K_c	Observed Strength	%s	(o − c)%	R
1392.24420	-5	6	2	4	7	3	5	1.01E-01	10	-6.2	1.04
1393.43949	0	4	3	1	5	4	2	4.50E-01	5	0.8	1.02
1394.51870	-4	9	2	8	10	1	9	{1.92E-02}			1.01
1394.78474	6	9	0	9	10	1	10	1.64E-01	3	-0.3	1.08
1394.8878	33	9	1	9	10	0	10	5.55E-02	3	1.2	1.08
1396.39464	-4	4	2	3	5	3	2	1.21E-00	3	5.7	1.06
1399.78515	-5	9	3	7	10	2	8	7.04E-03	3	7.3	0.98
1402.63996	4	5	2	3	6	3	4	6.95E-01	3	0.8	1.05
1402.9421	0	13	2	12	13	3	11	3.77E-04	10	7.2	
1403.87027	0	13	1	12	13	2	11	1.05E-03	4	-0.8	1.24
1406.44390	-4	10	4	7	11	3	8	2.06E-03	3	2.4	0.91
1407.13095	-2	8	1	7	9	2	8	4.74E-02	3	-0.2	1.03
1408.44894	2	10	1	10	10	2	9	4.40E-02	4	-4.5	1.25
1408.97964	1	10	0	10	10	1	9	1.53E-02	3	-0.6	1.25
1409.49920	1	5	0	5	5	3	2	3.60E-02	5	-1.9	1.05
1412.92533	-1	8	2	7	9	1	8	1.34E-01	5	-4.7	1.02
1414.25976	0	8	0	8	9	1	9	1.20E-01	8	-6.1	1.07
1414.48953	1	8	1	8	9	0	9	3.77E-01	4	-1.4	1.08
1416.47805	-3	4	2	2	5	3	3	4.67E-01	4	2.0	1.05
1416.92252	1	3	3	1	4	4	0	8.27E-01	3	-0.2	1.01
1417.11994	2	3	3	0	4	4	1	2.48E-00	2	-0.3	1.02
1420.58725	-1	3	1	3	4	2	2	3.22E-01	3	6.0	1.08
1420.6413	-1	12	2	11	12	3	10	3.79E-03	10	0.7	1.19
1421.34723	0	7	1	6	8	2	7	3.20E-01	4	2.0	1.04
1422.4619	14	12	1	11	12	2	10	1.32E-03	10	3.9	1.19
1424.26631	-2	8	3	6	9	2	7	4.38E-02	5	-3.4	0.96
1427.26807	-1	3	2	2	4	3	1	7.95E-01	3	0.2	1.05
1428.8924	26	9	1	9	9	2	8	3.55E-02	4	-8.3	1.21
1430.02484	-1	9	0	9	9	1	8	1.08E-01	6	-7.7	1.21
1431.4359	-6	4	0	4	4	3	1	1.55E-02	3	-2.3	1.05
1432.34675	2	7	2	6	8	1	7	1.02E-01	4	1.1	1.03
1433.44661	5	7	0	7	8	1	8	7.92E-01	3	-1.2	1.08
1433.92821	3	6	1	5	7	2	6	2.07E-01	3	1.0	1.04
1433.96168	-3	7	1	7	8	0	8	2.75E-01	3	3.0	1.07
1434.27315	3	3	2	1	4	3	2	2.56E-00	3	1.9	1.05
1438.10561	12	11	2	10	11	3	9	4.20E-03	4	2.2	1.16
1439.9654	-2	9	4	6	10	3	7	1.75E-03	5	8.6	0.88
1441.60507	11	11	1	10	11	2	9	1.21E-02	3	-4.3	1.16
1444.49250	0	3	0	3	3	3	0	2.55E-02	6	2.6	1.04
1445.24437	-2	5	1	4	6	2	5	1.10E-00	3	1.6	1.05
1448.93958	-3	8	1	8	8	2	7	2.58E-01	3	-2.9	1.18
1450.2517	0	13	3	11	13	4	10	{1.93E-04}			
1451.30123	0	8	0	8	8	1	7	8.70E-02	5	-3.4	1.18
1452.23584	2	6	0	6	7	1	7	4.90E-01	5	-2.4	1.07
1452.73313	2	7	3	5	8	2	6	3.02E-02	2	4.0	0.96
1453.38420	0	6	1	6	7	0	7	1.47E-00	4	-2.2	1.07
1453.58544	-1	6	2	5	7	1	6	5.70E-01	3	1.6	1.03
1454.25981	3	2	2	1	3	3	0	4.12E-00	4	0.2	1.04
1455.07795	3	10	2	9	10	3	8	3.42E-02	4	-7.5	1.13
1455.66689	7	2	2	0	3	3	1	1.38E-00	3	-0.3	1.04
1456.5269	-4	4	1	3	5	2	4	{5.80E-01}			1.05
1461.55073	21	10	1	9	10	2	8	1.26E-02	4	-2.4	1.13
1461.91157	1	2	1	2	3	2	1	2.09E-00	3	-1.2	1.07
1464.2099	-18	12	3	10	12	4	9	2.25E-03	4	1.8	1.10
1468.34393	1	7	1	7	7	2	6	1.85E-01	7	0.0	1.14
1469.26528	1	3	1	2	4	2	3	2.63E-00	3	1.5	1.06
1470.42866	4	5	0	5	6	1	6	2.55E-00	3	1.3	1.07
1471.18461	0	9	2	8	9	3	7	3.29E-02	3	-1.3	1.10
1472.93562	4	5	1	5	6	0	6	8.41E-01	3	1.0	1.07
1473.05147	3	7	0	7	7	1	6	5.57E-01	5	-3.2	1.14
1476.39769	17	8	4	5	9	3	6	{1.01E-02}			0.86
1477.08214	5	11	3	9	11	4	8	2.54E-03	4	-0.7	1.07
1477.55485	-1	5	2	4	6	1	5	2.91E-01	3	1.6	1.03
1477.7259	62	12	2	10	12	3	9	8.15E-04	10	-0.8	1.09
1477.9383	13	10	5	6	11	4	7	4.16E-04	10	-6.4	
1482.41243	5	9	1	8	9	2	7	1.10E-01	4	-0.1	1.10
1484.51095	1	2	1	1	3	2	2	1.18E-00	3	-1.2	1.05
1484.78062	2	6	3	4	7	2	5	1.40E-01	3	1.5	0.96
1485.94502	2	8	2	7	8	3	6	2.42E-01	5	-1.0	1.08
1486.71569	-2	6	1	6	6	2	5	1.04E-00	4	-0.8	1.11
1487.73172	0	4	0	4	5	1	5	1.23E-00	2	-0.2	1.07
1488.36332	3	10	3	8	10	4	7	2.33E-02	3	-2.7	1.05
1492.6140	-13	12	4	9	12	5	8	1.17E-03	6	-0.9	1.02
1492.96538	-2	4	1	4	5	0	5	3.68E-00	3	1.9	1.07
1495.40097	4	6	0	6	6	1	5	3.72E-01	3	-1.6	1.12
1495.88382	-1	1	1	1	2	2	0	1.29E-00	3	-1.6	1.05
1497.52335	3	11	2	9	11	3	8	9.20E-03	4	-1.4	1.08
1497.66307	5	9	3	7	9	4	6	2.18E-02	2	-1.3	1.03
1498.83510	9	7	2	6	7	3	5	{1.77E-01}			1.05
1499.2850	50	10	1	10	9	2	7	3.56E-04	10	-0.2	
1502.72747	0	1	1	0	2	2	1	4.74E-00	3	2.0	1.05
1503.0445	-1	9	0	9	8	3	6	7.00E-04	15	-23.6	0.78
1503.26145	3	10	4	7	10	5	6	1.27E-02	5	0.4	0.96
1503.52675	-3	5	1	5	5	2	4	5.88E-01	4	-0.3	1.09
1503.65536	3	8	1	7	8	2	6	9.29E-02	4	-4.9	1.09
1503.95602	-1	3	0	3	4	1	4	4.90E-00	4	3.7	1.07
1504.68970	3	4	2	3	5	1	4	1.06E-00	2	2.2	1.04
1504.74125	0	8	3	6	8	4	5	1.56E-01	3	-2.9	1.01
1505.6445	-7	6	5	2	6	6	1	{6.22E-02}			0.83
1505.6674	-53	6	5	1	6	6	0	{2.07E-02}			0.83
1505.68915	-1	7	5	3	7	6	2	{1.74E-02}			0.83
1505.8175	4	7	5	2	7	6	1	{5.21E-02}			0.83
1505.84837	11	8	5	4	8	6	3	{2.98E-02}			0.83
1505.89656	1	9	4	6	9	5	5	{1.13E-02}			0.94
1506.03797	2	9	5	5	9	6	4	4.77E-03	3	4.3	0.85
1506.06260	-5	10	5	6	10	6	5	5.47E-03	3	2.2	0.87
1506.34424	1	8	5	3	8	6	2	1.05E-02	4	5.6	0.84
1507.16725	-3	8	4	5	8	5	4	{7.84E-02}			0.93
1507.33904	0	5	4	2	5	5	1	7.25E-02	15	-15.6	0.91
1507.51045	8	5	4	1	5	5	0	{2.52E-01}			0.91
1508.27299	9	6	4	2	6	5	1	6.70E-02	15	-18.1	0.91
1508.3566	-22	9	6	3	9	7	2	5.00E-03	5	9.8	0.75
1508.37176	-12	8	6	3	8	7	2	9.10E-03	2	2.3	0.74
1508.39105	-11	8	6	2	8	7	1	3.10E-03	5	4.5	0.74
1509.39922	0	6	2	5	6	3	4	1.04E-00	5	3.5	1.04
1509.58755	1	7	3	5	7	4	4	9.85E-02	6	-12.5	1.00
1509.9006	61	10	5	5	10	6	4	1.80E-03	10	0.6	0.87
1510.09010	-1	7	4	3	7	5	2	1.50E-01	6	-1.6	0.92
1511.6447	-4	5	1	4	4	4	1	8.30E-04	10	-8.7	0.87
1512.45278	1	6	3	4	6	4	3	5.55E-01	5	-5.3	0.99
1513.65316	-1	8	4	4	8	5	3	2.65E-02	3	0.8	0.93
1513.81311	0	5	3	3	5	4	2	2.80E-01	3	2.7	0.98
1514.04494	0	3	1	3	4	0	4	1.48E-00	2	1.6	1.07
1514.25426	0	4	3	2	4	4	1	7.80E-01	3	0.2	0.98
1514.4329	47	10	7	4	10	8	3	5.82E-04	10	4.8	0.67
1514.447	91	10	7	3	10	8	2	1.94E-04	10	4.8	
*1515.2951	4	8	7	2	8	8	1	{2.44E-03}			0.66
1515.36195	1	4	3	1	4	4	0	2.83E-01	4	8.4	0.98
1516.27428	3	10	2	8	10	3	7	{1.10E-02}			1.05
1517.37201	0	5	2	4	5	3	3	{5.36E-01}			1.03
1517.79420	2	5	0	5	5	1	4	2.25E-00	5	7.1	1.10
1518.18742	-5	4	1	4	4	2	3	2.63E-00	2	1.1	1.07
1519.01160	0	5	3	3	6	2	4	6.40E-02	5	6.8	0.97
1519.45142	8	9	4	5	9	5	4	3.33E-02	3	-3.8	0.94
1519.55708	0	2	0	2	3	1	3	1.90E-00	3	8.3	1.07
1522.51227	9	6	3	3	6	4	2	2.05E-01	5	1.8	0.98
1522.76315	1	4	2	3	4	3	2	{2.05E-00}			1.02
1523.62186	-1	7	1	6	7	2	5	6.98E-01	3	-4.0	1.07
1525.88245	4	3	2	2	3	3	1	5.96E-01	5	-0.2	1.02
1527.0593	26	10	4	6	10	5	5	4.55E-03	5	3.8	0.96
1528.86525	4	7	0	7	6	3	4	4.95E-03	5	-2.2	0.86
1529.38025	2	7	3	4	7	4	3	3.55E-01	3	-1.1	0.99
1530.0502	-9	4	0	4	3	3	1	2.15E-03	3	7.6	0.96
1530.18393	0	3	1	3	3	2	2	1.05E-00	2	-0.1	1.06
1531.31127	-2	3	2	1	3	3	0	1.85E-00	3	-0.4	1.02
1531.78812	0	9	2	7	9	3	6	9.35E-02	6	-13.0	1.04
1534.31352	0	3	2	2	4	1	3	3.08E-01	4	-1.2	1.04
1534.7799	34	11	4	7	11	5	6	4.38E-03	10	1.2	0.97
1534.7855	25	6	1	5	5	4	2	{8.51E-04}			0.84
1535.21804	-4	6	0	6	5	3	3	3.05E-03	4	3.3	0.90
1535.88778	0	1	0	1	2	1	2	5.07E-00	3	-1.1	1.07
1536.48181	4	4	2	2	4	3	1	7.55E-01	4	-0.6	1.02
1536.67101	3	8	3	5	8	4	4	6.00E-02	5	-0.3	1.00
1536.80971	-1	2	1	2	3	0	3	3.95E-00	2	-3.2	1.07
1538.48143	3	4	0	4	4	1	3	1.24E-00	3	2.0	1.09
1538.61105	-11	11	3	8	11	4	7	7.40E-03	5	-3.4	1.02

Table 6. *Continued*

Observed Position	o − c	Upper J	Upper K_a	Upper K_c	Lower J	Lower K_a	Lower K_c	Observed Strength	%s	(o − c)%	R
1539.20209	2	2	1	2	2	2	1	{2.70E-00}			1.04
1539.98378	4	6	1	5	6	2	4	5.21E-01	4	-4.7	1.06
1541.8427	0	9	3	6	9	4	5	6.87E-02	15	-10.2	0.99
1542.30694	6	8	2	6	8	3	5	9.10E-02	10	-9.8	1.04
1542.53779	6	5	2	3	5	3	2	1.98E-00	4	0.9	1.02
1542.83513	-25	10	3	7	10	4	6	8.93E-03	3	1.4	1.01
1546.86822	1	6	2	4	6	3	3	4.47E-01	3	1.3	1.03
1547.20788	0	7	2	5	7	3	4	7.25E-01	3	3.0	1.04
1549.0952	-6	9	4	5	10	3	8	1.26E-03	5	-0.8	0.75
1550.70253	1	6	4	3	7	3	4	3.04E-02	4	3.9	0.87
1551.0604	7	5	1	4	5	2	3	3.17E-00	10	0.7	1.06
1551.2143	5	8	1	8	7	2	5	3.94E-03	5	-0.4	0.85
1551.2941	6	7	1	6	6	4	3	3.16E-03	10	-0.8	0.81
1551.3821	9	8	4	4	9	3	7	1.50E-03	10	-0.7	0.78
1553.4407	18	8	5	4	9	4	5	2.52E-03	5	4.9	0.73
1553.66987	2	4	3	2	5	2	3	1.76E-01	4	-4.6	0.98
1554.3945	-4	0	0	0	1	1	1	{1.43E-00}			1.05
1554.5616	2	2	1	1	2	2	0	{1.27E-00}			1.04
1555.15017	0	3	0	3	3	1	2	5.63E-00	3	-1.6	1.07
1556.57647	0	4	1	3	4	2	2	1.71E-00	3	6.8	1.05
1557.26842	1	3	1	2	3	2	1	5.35E-00	4	0.0	1.05
1560.5096	-16	8	1	7	7	4	4	6.14E-04	15	-28.9	0.79
1561.31037	3	1	1	1	2	0	2	7.40E-01	4	-9.0	1.07
1561.56404	-4	7	4	3	8	3	6	1.30E-02	3	5.6	0.82
1562.8874	10	9	1	8	8	4	5	1.12E-03	3	-8.7	0.77
1564.91745	0	2	2	1	3	1	2	{5.32E-01}			1.04
1566.48900	5	2	0	2	2	1	1	2.56E-00	4	5.7	1.07
1569.30765	2	6	3	3	7	2	6	1.14E-02	5	5.0	0.91
1572.92819	1	1	0	1	1	1	0	6.35E-00	3	-0.9	1.06
1573.56947	2	5	3	2	6	2	5	7.55E-02	3	-3.7	0.95
1574.02422	3	7	3	4	8	2	7	1.01E-02	4	4.2	0.86
1574.0356	-7	8	5	3	9	4	6	9.36E-04	15	20.5	0.71
1574.3994	-8	7	1	7	6	2	4	4.05E-03	10	-8.7	0.90
1577.77598	-7	6	4	2	7	3	5	8.88E-03	5	7.4	0.85
1584.97285	-1	5	4	2	6	3	3	1.30E-02	4	4.9	0.90
1585.47077	1	4	3	1	5	2	4	4.12E-02	3	0.2	0.98
1586.56447	6	7	5	3	8	4	4	1.55E-03	4	2.1	0.75
1587.08088	2	3	3	1	4	2	2	4.22E-02	3	2.7	1.01
1587.5885	-30	8	3	5	9	2	8	7.77E-04	10	1.2	0.79
1590.77482	0	3	2	1	4	1	4	1.72E-01	3	0.6	1.05
1592.53170	5	6	1	6	5	2	3	4.37E-02	3	2.0	0.94
1592.77750	-3	4	2	2	5	1	5	2.60E-02	3	1.0	1.02
1596.14785	0	7	5	2	8	4	5	4.60E-03	10	3.0	0.74
1596.4970	-44	9	6	3	10	5	6	3.09E-04	15	5.8	
1597.32608	1	2	2	0	3	1	3	6.80E-02	5	0.1	1.06
1598.06232	0	5	4	1	6	3	4	3.55E-02	3	0.7	0.90
1600.23459	2	3	1	3	2	2	0	1.08E-01	6	4.3	1.01
1602.8901	7	3	3	0	4	2	3	1.12E-01	6	5.7	1.01
1603.46713	-3	5	2	3	6	1	6	2.53E-02	4	-1.1	0.99
1603.5764	9	5	1	5	4	2	2	4.21E-02	3	2.5	0.98
1606.19062	1	4	1	4	3	2	1	2.70E-01	4	1.4	1.00
1608.5991	-92	9	3	6	10	2	9	4.40E-04	15	-11.6	0.73
1613.09923	0	1	1	0	1	0	1	5.67E-00	3	-3.2	1.07
1615.75800	2	4	4	1	5	3	2	2.92E-02	5	-1.9	0.93
1616.1141	1	6	5	2	7	4	3	7.15E-03	4	6.3	0.78
1617.8825	-63	8	6	3	9	5	4	{6.09E-04}			0.65
1619.80127	-4	4	2	3	3	3	0	2.02E-01	8	-0.8	0.97
1619.98808	-1	2	1	1	2	0	2	2.17E-00	3	3.7	1.08
1620.3637	136	8	6	2	9	5	5	1.56E-04	15	-30.1	
1620.7732	15	4	4	0	5	3	3	9.90E-03	4	0.9	0.93
1621.69306	0	6	2	4	7	1	7	2.22E-03	5	-9.5	0.93
1624.52838	0	2	0	2	1	1	1	1.10E-00	5	6.0	1.06
1631.31498	-3	1	1	1	0	0	0	1.54E-00	4	3.5	1.07
1632.16655	-2	3	1	2	3	0	3	4.60E-00	3	1.5	1.09
1634.55892	0	3	1	2	2	2	1	8.40E-01	4	3.3	1.02
1635.09607	-3	4	2	2	3	3	1	7.35E-02	5	-7.7	0.97
1635.73544	-12	5	3	3	4	4	0	{2.39E-02}			0.89
1636.0899	12	9	2	8	8	3	5	1.82E-03	4	1.3	0.83
1637.37570	0	5	2	4	4	3	1	8.16E-02	6	-1.4	0.94
1639.96981	1	5	3	2	4	4	1	7.34E-02	5	0.5	0.89
1641.96895	-1	3	2	1	3	1	2	4.05E-00	3	-0.6	1.07
1642.9671	10	5	5	1	6	4	2	2.05E-03	4	1.6	0.84
1643.52724	3	4	2	2	4	1	3	1.18E-00	3	-0.3	1.06
1643.6954	10	7	6	2	8	5	3	{3.31E-04}			
1644.07605	0	5	5	0	6	4	3	6.40E-03	4	5.6	0.83
1644.25793	-1	2	2	0	2	1	1	9.95E-01	4	1.1	1.07
1644.4910	3	7	6	1	8	5	4	9.75E-04	7	-1.9	0.69
1645.58177	-13	7	2	5	8	1	8	1.79E-03	5	-9.7	0.86
1648.86145	-1	8	2	7	7	3	4	2.22E-02	6	5.6	0.86
1649.03295	3	3	0	3	2	1	2	5.84E-00	3	1.0	1.05
1649.29702	-1	6	2	5	5	3	2	1.60E-01	4	-1.0	0.92
1649.57382	-1	2	1	2	1	0	1	6.10E-00	3	0.3	1.07
1650.03419	4	4	1	3	4	0	4	8.55E-01	5	-1.0	1.11
1650.83278	6	5	2	3	5	1	4	2.18E-00	3	-0.6	1.07
1653.45886	-11	7	2	6	6	3	3	{2.27E-02}			0.88
1653.94327	3	6	4	3	5	5	0	1.94E-02	3	2.6	0.81
1654.76613	-6	6	4	2	5	5	1	6.40E-03	5	1.4	0.81
1658.76045	-2	6	3	4	5	4	1	9.26E-02	4	1.2	0.87
1658.80020	0	2	2	1	2	1	2	2.00E-00	3	-2.4	1.09
1664.85817	0	6	2	4	6	1	5	3.55E-01	6	3.1	1.07
1665.66108	0	3	1	3	2	0	2	2.41E-00	3	0.5	1.06
1666.17315	1	4	1	3	3	2	2	5.14E-01	3	2.6	1.01
1667.54165	-1	3	2	2	3	1	3	7.27E-01	5	-3.7	1.10
1668.3668	-22	6	6	1	7	5	2	9.40E-04	10	-6.5	0.75
1668.90618	-1	5	2	3	4	3	2	3.68E-01	3	-0.7	0.95
1670.16466	-4	6	3	3	5	4	2	3.39E-02	3	4.8	0.87
1671.70953	-1	4	0	4	3	1	3	2.26E-00	3	-2.9	1.05
1672.19278	0	5	1	4	5	0	5	1.29E-00	3	-3.1	1.13
1674.80232	2	4	3	2	5	0	5	6.33E-03	3	-7.6	1.03
1675.2532	2	5	3	3	6	0	6	{1.74E-03}			0.97
1675.36301	-18	6	3	3	6	2	4	2.60E-01	10	-2.5	1.04
1676.29878	-5	7	3	4	7	2	5	4.15E-01	3	0.2	1.04
1676.7376	100	7	5	3	6	6	0	1.50E-03	10	10.7	0.75
1676.8708	31	7	5	2	6	6	1	4.40E-03	5	8.5	0.75
1678.48565	0	7	4	4	6	5	1	7.90E-03	4	4.3	0.79
1679.26487	3	4	2	3	4	1	4	1.69E-00	3	-3.0	1.11
1679.38538	-1	5	3	2	5	2	3	1.18E-00	3	-1.9	1.04
1679.4174	14	7	3	5	6	4	2	2.40E-02	10	6.4	0.85
1681.08883	6	4	1	4	3	0	3	7.44E-00	4	-0.5	1.05
1681.26780	18	7	4	3	6	5	2	2.25E-02	5	-1.5	0.79
1684.11314	-2	8	3	5	8	2	6	5.40E-02	5	-2.3	1.04
1685.18677	-1	7	2	5	7	1	6	4.18E-01	10	3.1	1.09
1685.52027	-2	4	3	1	4	2	2	4.64E-01	3	-2.5	1.05
1688.6816	18	6	4	3	7	1	6	1.55E-03	10	-9.8	0.83
1690.89317	0	3	3	0	3	2	1	1.17E-00	3	-2.6	1.06
1692.36933	-2	5	0	5	4	1	4	6.30E-00	4	-4.0	1.04
1693.67138	-8	5	2	4	5	1	5	3.30E-01	10	-10.3	1.14
1695.84058	-2	2	2	1	1	1	0	{4.56E-00}			1.07
1696.22532	0	6	1	5	6	0	6	1.95E-01	7	-10.2	1.16
1696.67753	0	3	3	1	3	2	2	3.60E-01	7	-7.2	1.07
1697.03400	1	5	1	5	4	0	4	2.24E-00	3	0.2	1.05
1697.41477	-8	5	1	4	4	2	3	1.75E-00	3	-1.2	1.00
1699.4356	0	9	3	6	9	2	7	5.25E-02	3	-1.3	1.05
1700.02428	-9	4	3	2	4	2	3	{1.23E-00}			1.02
1701.1777	-25	8	5	4	7	6	1	5.13E-03	15	15.5	0.72
1701.7119	13	8	5	3	7	6	2	1.46E-03	5	0.5	0.72
1702.29734	-3	2	2	0	1	1	1	1.30E-00	4	4.8	1.05
1702.4110	33	8	4	5	7	5	2	1.44E-02	10	-13.0	0.78
1702.9635	68	5	4	2	6	1	5	4.52E-04	10	-0.3	
1703.9710	0	7	3	4	6	4	3	8.28E-02	5	2.7	0.87
1704.1492	6	8	6	3	7	7	0	7.35E-04	10	11.2	0.65
1704.1692	5	8	6	2	7	7	1	2.01E-04	10	-8.6	
1704.67535	3	6	2	4	5	3	3	1.25E-01	5	1.0	0.94
1705.84434	-4	5	3	3	5	2	4	3.00E-01	3	-2.4	1.04
1706.2144	3	9	3	7	8	4	4	4.23E-03	10	-3.0	0.80
1708.4960	21	10	3	8	9	4	5	3.86E-03	4	6.4	0.77
1709.86498	-1	8	2	6	8	1	7	4.79E-02	3	0.5	1.10
1709.8903	9	8	4	4	7	5	3	5.85E-03	4	3.8	0.78
1710.2264	-6	6	2	5	6	1	6	5.30E-01	10	-5.3	1.10
1710.8677	-18	9	4	5	9	3	6	3.52E-02	4	-5.3	1.03
1711.0864	-15	10	4	6	10	3	7	4.25E-03	3	0.1	1.04
1711.51750	-3	6	0	6	5	1	5	1.70E-00	3	0.6	1.02
1713.66409	-1	6	1	6	5	0	5	5.20E-00	3	1.7	1.02
1714.47352	-1	3	2	2	2	1	1	1.33E-00	4	2.6	1.04
1714.54851	2	6	3	4	6	2	5	5.60E-01	5	2.9	1.05
1716.28720	2	8	4	4	8	3	5	3.04E-02	4	3.6	1.02

(continued overleaf)

Table 6. *Continued*

Observed Position	o − c	Upper J	Upper K_a	Upper K_c	Lower J	Lower K_a	Lower K_c	Observed Strength	%s	(o − c)%	R
1720.05828	3	7	1	6	7	0	7	2.60E-01	7	-7.0	1.13
1721.36901	0	10	3	7	10	2	8	4.93E-03	2	-0.5	1.09
1724.0533	33	4	4	1	5	1	4	4.80E-04	10	-13.1	0.81
1724.48049	-5	7	4	3	7	3	4	1.77E-01	3	0.8	1.02
1724.8310	6	9	4	6	8	5	3	3.20E-03	8	9.5	0.77
1725.5506	4	9	5	5	8	6	2	1.00E-03	5	2.7	0.71
1726.21270	-1	7	3	5	7	2	6	8.80E-02	8	-1.3	1.07
1726.81652	0	6	1	5	5	2	4	4.70E-01	15	-13.6	0.98
1727.2446	3	9	5	4	8	6	3	2.62E-03	10	-11.3	0.71
1728.1508	5	9	6	3	8	7	2	7.44E-04	10	10.8	0.64
1728.28381	-1	7	2	6	7	1	7	9.10E-02	6	2.1	1.13
1729.69243	-2	7	0	7	6	1	6	3.54E-00	3	1.5	1.02
1730.45898	0	4	2	3	3	1	2	3.33E-00	3	1.8	1.03
1730.64110	4	7	1	7	6	0	6	1.18E-00	5	1.2	1.02
1732.40005	4	6	4	2	6	3	3	1.02E-01	6	2.0	1.01
1735.85173	2	3	2	1	2	1	2	2.24E-00	5	0.1	1.05
1736.25564	6	9	2	7	9	1	8	4.58E-02	4	-4.7	1.12
1737.96015	2	5	4	1	5	3	2	4.40E-01	4	4.6	1.00
1740.57736	-1	8	3	6	8	2	7	1.07E-01	8	-5.7	1.09
1740.77672	-2	4	4	0	4	3	1	1.35E-01	10	-0.3	1.00
1740.9677	11	8	3	5	7	4	4	1.65E-02	6	-6.9	0.87
1741.00062	7	7	2	5	6	3	4	2.75E-01	5	-8.4	0.94
1741.6377	6	9	4	5	8	5	4	9.80E-03	5	3.5	0.79
1742.12645	1	4	4	1	4	3	2	3.90E-01	5	-3.8	1.00
1742.7526	-12	8	1	7	8	0	8	3.82E-02	3	-2.8	1.15
1742.77994	-3	5	4	2	5	3	3	1.42E-01	3	2.3	1.01
1744.42122	8	5	2	4	4	1	3	8.30E-01	6	-3.9	1.02
1744.49523	4	6	4	3	6	3	4	2.95E-01	5	1.9	1.01
1747.65063	0	8	1	8	7	0	7	2.13E-00	3	0.1	1.02
1747.6838	35	11	3	8	11	2	9	4.07E-03	10	8.7	1.12
1747.9888	0	7	4	4	7	3	5	5.37E-02	3	1.0	1.03
1749.5510	-5	10	5	6	9	6	3	1.39E-03	4	-4.6	0.71
1751.9203	-45	10	6	5	9	7	2	3.65E-04	10	-10.6	
1753.38976	0	7	1	6	6	2	5	1.18E-00	4	0.1	0.99
1753.88470	6	8	4	5	8	3	6	6.84E-02	5	-6.4	1.04
1754.9047	-29	11	5	6	11	4	7	1.70E-03	3	-1.2	1.03
1757.13217	-2	9	3	7	9	2	8	1.44E-02	5	2.0	1.12
1757.59198	-4	6	2	5	5	1	4	1.90E-00	7	-0.3	1.02
1759.4646	61	11	4	8	10	5	5	3.91E-04	10	2.1	
1762.20272	-2	10	2	8	10	1	9	5.15E-03	3	1.8	1.16
1762.55973	-5	9	4	6	9	3	7	9.57E-03	5	1.3	1.07
1764.27331	-2	9	1	8	9	0	9	4.10E-02	5	-11.3	1.19
1764.33504	5	9	0	9	8	1	8	1.18E-00	5	1.8	1.02
1764.51381	-8	9	1	9	8	0	8	3.98E-01	5	2.9	1.02
1764.85788	1	10	5	5	10	4	6	1.74E-03	6	0.3	1.03
1765.79133	0	3	3	0	3	0	3	2.33E-02	5	5.1	1.04
1766.6064	-2	9	2	8	9	1	9	1.55E-02	6	2.3	1.18
1766.72815	-2	3	3	1	2	2	0	1.24E-00	4	2.5	1.04
1768.18368	0	3	3	0	2	2	1	(3.60E-00)			1.03
1771.44894	1	7	2	6	6	1	5	4.27E-01	5	1.0	1.00
1774.07005	15	10	4	7	10	3	8	9.50E-03	3	-0.3	1.09
1774.8369	7	9	5	4	9	4	5	1.43E-02	4	3.1	1.02
1775.25311	0	10	3	8	10	2	9	1.40E-02	3	-1.3	1.16
1776.35326	-1	8	2	6	7	3	5	6.55E-02	4	-2.1	0.94
1776.75534	-1	4	2	2	3	1	3	3.60E-01	4	2.2	1.07
1777.0177	2	10	4	6	9	5	5	1.47E-03	6	1.3	0.79
1777.13493	0	8	1	7	7	2	6	2.36E-01	6	-2.4	0.98
1778.9780	3	4	3	1	4	0	4	1.42E-02	5	4.4	1.05
1779.91059	7	9	3	6	8	4	5	2.97E-02	3	0.7	0.87
1781.06729	-2	10	0	10	9	1	9	1.98E-01	5	4.3	1.02
1781.14541	-4	10	1	10	9	0	9	6.02E-01	5	5.6	1.02
1782.58707	5	8	5	3	8	4	4	1.13E-02	2	4.8	1.00
1783.0295	3	11	5	6	10	6	5	4.78E-04	15	-25.3	0.70
1786.07778	-5	10	2	9	10	1	10	1.56E-02	5	-4.7	1.23
1786.6727	-10	11	2	9	11	1	10	4.40E-03	4	-1.6	1.20
1786.84039	3	8	2	7	7	1	6	7.50E-01	4	0.3	1.00
1787.33995	-6	7	5	2	7	4	3	6.30E-02	4	-1.5	0.99
1788.02750	-1	4	3	2	3	2	1	2.55E-00	5	3.4	1.04
1788.1631	-4	11	4	8	11	3	9	(9.58E-04)			1.14
1789.62208	1	6	5	1	6	4	2	3.50E-02	3	3.2	0.98
1790.38376	1	5	5	0	5	4	1	1.12E-01	5	2.0	0.97
1790.61953	1	5	5	1	5	4	2	3.65E-02	4	-0.2	0.97
1790.70491	5	6	5	2	6	4	3	1.03E-01	3	1.4	0.98
1790.86107	5	7	5	3	7	4	4	2.08E-02	6	-2.2	0.99
1791.50832	-2	8	5	4	8	4	5	3.15E-02	3	-1.5	1.00
1793.24203	3	9	5	5	9	4	6	4.62E-03	5	3.2	1.02
1794.3374	-2	11	3	9	11	2	10	1.55E-03	4	7.6	1.20
1795.11698	2	4	3	1	3	2	2	8.25E-01	8	5.9	1.04
1796.70507	4	10	5	6	10	4	7	4.70E-03	6	-2.4	1.04
1797.47377	-1	11	0	11	10	1	10	2.40E-01	6	-5.0	1.02
1797.50833	1	11	1	11	10	0	10	7.65E-02	3	-9.5	1.02
1798.72343	1	9	1	8	8	2	7	3.84E-01	5	-0.1	0.98
1800.51783	-1	5	3	2	5	0	5	3.18E-02	3	1.5	1.06
1803.64788	-1	9	2	8	8	1	7	1.35E-01	5	3.9	0.98
1804.3633	-2	12	4	9	12	3	10	8.37E-04	15	7.9	
1804.86632	1	11	1	10	11	0	11	5.50E-03	5	1.5	1.28
1805.46211	-11	11	2	10	11	1	11	1.85E-03	6	2.7	1.28
1805.89400	9	5	3	3	4	2	2	5.25E-01	4	2.1	1.04
1809.27525	1	9	2	7	8	3	6	1.13E-01	4	-0.7	0.94
1809.5671	-31	12	2	10	12	1	11	4.33E-04	10	6.2	
1810.7496	1	12	5	8	12	4	9	3.20E-04	15	-28.1	
1813.5722	-1	12	0	12	11	1	11	3.18E-02	3	-6.2	1.03
1813.58783	-1	12	1	12	11	0	11	9.70E-02	4	-4.6	1.03
1813.8911	-7	12	3	10	12	2	11	1.22E-03	7	2.0	1.26
1815.5939	3	11	4	7	10	5	6	1.68E-03	3	-2.8	0.79
1818.89748	-3	10	1	9	9	2	8	5.96E-02	4	-0.3	0.98
1819.24678	-5	10	3	7	9	4	6	4.97E-03	4	4.2	0.87
1820.36442	-1	6	3	4	5	2	3	9.20E-01	4	1.3	1.03
1821.31803	3	10	2	9	9	1	8	1.88E-01	5	4.1	0.97
1824.3627	9	12	1	11	12	0	12	5.64E-04	10	2.8	
1824.6620	4	12	2	11	12	1	12	1.55E-03	3	-5.9	1.34
1825.40788	-1	5	2	3	4	1	4	3.98E-01	5	-4.3	1.08
1825.73994	3	5	3	2	4	2	3	1.24E-00	3	-2.2	1.06
1829.3719	5	13	0	13	12	1	12	3.60E-02	5	-3.0	1.03
1829.3784	-19	13	1	13	12	0	12	1.18E-02	5	-4.7	1.03
1831.1733	10	13	2	11	13	1	12	2.80E-04	10	-9.7	
1831.60473	-4	6	3	3	6	0	6	4.98E-03	5	9.9	1.07
1832.1547	2	3	3	1	2	0	2	8.10E-03	4	3.9	1.09
1832.26828	1	7	3	5	6	2	4	1.72E-01	3	1.7	1.01
1834.0475	5	10	6	4	10	5	5	5.48E-04	10	-11.4	
1837.66210	10	9	6	3	9	5	4	4.99E-03	3	3.2	0.98
1838.18931	-4	11	1	10	10	2	9	7.00E-02	6	-6.5	0.97
1838.86858	-3	10	2	8	9	3	7	1.84E-02	3	0.7	0.93
1839.16453	-8	4	4	1	3	3	0	1.89E-00	3	-4.6	1.03
1839.2965	-23	8	6	2	8	5	3	3.14E-03	10	-12.7	0.97
1839.3621	-24	11	2	10	10	1	9	2.40E-02	10	-4.0	0.97
1839.39102	-5	4	4	0	3	3	1	6.39E-01	3	-3.1	1.03
1839.5086	-30	6	6	0	6	5	1	7.48E-03	5	-2.0	0.94
1839.54453	0	6	6	1	6	5	2	2.26E-02	3	-1.2	0.94
1839.73431	-5	7	6	1	7	5	2	1.90E-02	4	0.0	0.95
1839.9322	-14	7	6	2	7	5	3	6.68E-03	10	5.4	0.95
1840.0316	-2	9	6	4	9	5	5	1.64E-03	4	2.0	0.98
1840.0620	63	10	6	5	10	5	6	1.75E-03	10	-4.8	1.01
1840.0695	7	8	6	3	8	5	4	1.12E-02	5	4.6	0.97
1842.85198	-3	8	3	6	7	2	5	2.70E-01	4	0.7	0.99
1843.4834	-3	13	1	12	13	0	13	4.88E-04	10	5.6	
*1844.88188	-17	14	1	14	13	0	13	1.67E-02	6	1.5	1.03
1846.25507	-5	5	4	1	5	1	4	8.23E-03	4	3.9	1.03
1847.8217	-48	4	4	0	4	1	3	(8.98E-04)			1.02
1850.39005	8	6	4	2	6	1	5	3.65E-03	5	3.8	1.04
1853.65656	1	9	3	7	8	2	6	4.46E-02	3	1.5	0.97
1856.91502	0	12	1	11	11	2	10	9.67E-03	4	3.4	0.97
1857.37810	8	11	3	8	10	4	7	6.30E-03	3	3.4	0.87
1857.4821	1	12	2	11	11	1	10	2.67E-02	3	-5.0	0.97
*1860.10015	0	15	0	15	14	1	14	5.20E-03	4	4.1	1.04
1862.19591	-6	6	3	3	5	2	4	1.77E-01	3	-4.0	1.06
1862.4594	-4	7	4	3	7	1	6	7.92E-03	5	2.6	1.06
1862.78358	-8	5	4	2	4	3	1	3.89E-01	3	-1.7	1.04
1862.92565	-2	4	3	2	3	0	3	6.32E-02	4	2.1	1.09
1864.32853	-6	5	4	1	4	3	2	1.13E-00	3	-4.5	1.04
1865.1493	2	11	2	9	10	3	8	2.31E-02	5	1.6	0.93
1866.08865	-4	10	3	8	9	2	7	5.90E-02	3	0.1	0.95
1872.73519	-2	7	3	4	7	0	7	4.00E-03	5	4.6	1.08
*1875.0402	0	16	1	16	15	0	15	1.50E-03	6	8.3	1.04
1875.24738	3	13	1	12	12	2	11	9.65E-03	4	1.4	0.97
1875.52310	0	13	2	12	12	1	11	3.30E-03	4	3.9	0.97

Table 6. *Continued*

Observed Position	o − c	Upper J	Upper K_a	Upper K_c	Lower J	Lower K_a	Lower K_c	Observed Strength	%s	(o − c)%	R
1880.7525	15	11	3	9	10	2	8	7.90E-03	4	0.6	0.94
1880.97476	-1	6	2	4	5	1	5	5.03E-02	5	2.4	1.10
1883.8454	11	8	4	4	8	1	7	1.13E-03	6	-0.4	1.07
1884.39296	-4	6	4	3	5	3	2	6.30E-01	3	-0.8	1.04
1887.5239	7	7	7	0	7	6	1	4.00E-03	5	6.2	0.93
1887.5293	44	7	7	1	7	6	2	1.33E-03	5	6.0	0.92
1888.4226	-3	8	7	1	8	6	2	9.30E-04	6	-0.5	0.94
1888.45488	14	8	7	2	8	6	3	2.75E-03	4	-1.9	0.94
1888.7942	0	12	2	10	11	3	9	2.80E-03	10	1.8	0.92
1888.9607	-9	9	7	2	9	6	3	1.49E-03	6	4.8	0.95
1889.1069	20	9	7	3	9	6	4	5.40E-04	15	13.9	
1889.4153	-15	10	7	4	10	6	5	3.96E-04	15	-42.9	
*1889.7052	0	17	0	17	16	1	16	4.47E-04	15	21.9	
1890.20704	-8	6	4	2	5	3	3	2.16E-01	3	3.9	1.04
1893.2794	0	14	1	13	13	2	12	9.78E-04	10	0.1	0.97
1893.4147	0	14	2	13	13	1	12	2.80E-03	10	-4.6	0.96
1897.34328	0	12	3	10	11	2	9	8.30E-03	4	-1.2	0.93
1898.6287	56	4	4	1	4	1	4	4.74E-04	10	-12.0	
1899.3516	1	5	3	3	4	0	4	2.35E-02	5	-2.0	1.11
1902.6130	24	7	4	4	6	3	3	9.50E-02	6	-6.4	1.03
1906.06672	0	7	3	4	6	2	5	1.89E-01	5	-2.5	1.07
1910.61126	0	13	2	11	12	3	10	2.76E-03	6	3.5	0.92
1911.0634	0	15	1	14	14	2	13	7.86E-04	10	-4.6	0.97
1911.1313	0	15	2	14	14	1	13	2.12E-04	15	-29.2	
1912.54196	-1	5	5	1	4	4	0	2.40E-01	4	-3.5	1.04
1912.57211	-1	5	5	0	4	4	1	7.37E-01	4	-1.2	1.04
1915.1710	0	13	3	11	12	2	10	9.60E-04	10	6.9	0.92
1915.3350	-34	9	4	5	9	1	8	9.29E-04	10	-4.6	1.10
1916.80105	-5	8	4	5	7	3	4	1.31E-01	5	-1.2	1.02
1918.27321	0	7	4	3	6	3	4	2.69E-01	4	-5.0	1.04
1924.8299	0	13	3	10	12	4	9	7.36E-04	10	-0.8	0.87
1927.46495	0	9	4	6	8	3	5	1.78E-02	4	-1.4	0.99
1930.0293	10	8	5	3	8	2	6	2.88E-04	10	0.9	
1932.4298	7	9	5	4	9	2	7	5.22E-04	10	-9.9	
*1933.7380	-57	8	8	1	8	7	2	6.89E-04	10	4.1	
1934.2589	29	7	5	2	7	2	5	8.95E-04	6	7.4	1.04
*1935.2643	122	9	8	1	9	7	2	3.92E-04	15	-9.9	
1935.84245	-7	10	4	7	9	3	6	2.06E-02	4	-1.5	0.96
1937.01255	-1	6	5	2	5	4	1	3.94E-01	3	-1.1	1.04
1937.27446	-13	6	5	1	5	4	2	1.33E-01	5	0.2	1.04
1941.49690	2	6	3	4	5	0	5	5.22E-02	4	2.1	1.13
1941.82776	-3	7	2	5	6	1	6	4.95E-02	3	0.0	1.12
1943.4915	0	11	4	8	10	3	7	2.60E-03	7	2.5	0.94
1945.3228	37	6	4	3	6	1	6	6.29E-04	10	-2.6	
1949.8225	22	4	4	1	3	1	2	3.33E-03	10	10.1	1.13
1950.33355	-2	8	4	4	7	3	5	3.60E-02	4	0.7	1.04
1952.05463	1	12	4	9	11	3	8	2.45E-03	3	-4.9	0.92
1957.59275	-1	8	3	5	7	2	6	1.91E-02	4	0.4	1.08
1960.69075	1	7	5	3	6	4	2	6.42E-02	4	1.3	1.04
1961.93071	-7	7	5	2	6	4	3	1.85E-01	3	-2.5	1.04
1969.82920	10	5	4	2	4	1	3	3.10E-03	5	-1.5	1.14
1981.0508	48	4	4	0	3	1	3	5.09E-04	15	28.3	
1982.70042	-8	8	5	4	7	4	3	7.70E-02	6	-4.7	1.03
1985.9986	43	6	6	1	5	5	0	1.99E-01	3	-2.6	1.05
1986.0027	51	6	6	0	5	5	1	6.62E-02	3	-2.8	1.06
1986.88358	-5	8	5	3	7	4	4	2.78E-02	5	4.1	1.04
1988.35497	-3	9	4	5	8	3	6	3.33E-02	2	0.1	1.04
1988.5099	5	7	3	5	6	0	6	8.88E-03	5	0.1	1.14
1992.68788	-11	6	4	3	5	1	4	1.55E-02	3	0.1	1.15
2001.79333	-2	9	5	5	8	4	4	1.04E-02	4	2.4	1.02
2005.80201	-7	8	2	6	7	1	7	5.35E-03	3	-0.1	1.14
2010.87255	0	7	6	2	6	5	1	3.11E-02	3	-3.6	1.06
2010.91188	1	7	6	1	6	5	2	9.35E-02	7	-3.3	1.06
2012.90463	-2	9	5	4	8	4	5	2.92E-02	2	-1.3	1.03
2015.74648	-16	9	3	6	8	2	7	1.52E-02	2	1.8	1.09
2020.60271	-1	7	4	4	6	1	5	5.27E-03	5	2.0	1.15
2020.8305	21	5	4	1	4	1	4	1.95E-03	10	4.5	1.21
2027.5729	0	11	5	7	10	4	6	1.05E-03	10	-1.5	0.98
2033.6808	-11	10	4	6	9	3	7	3.05E-03	3	8.0	1.05
2034.8105	0	12	5	8	11	4	7	8.94E-04	10	-3.5	0.94
2035.31283	1	8	6	3	7	5	2	4.05E-02	3	-1.2	1.06
2035.53382	5	8	6	2	7	5	3	1.36E-02	3	-0.4	1.06
2039.28842	3	8	3	6	7	0	7	1.15E-02	3	2.1	1.17
2041.2693	-2	10	5	5	9	4	6	3.20E-03	4	1.9	1.02
2054.77997	-3	8	4	5	7	1	6	1.01E-02	5	0.0	1.16
*2058.57634	-52	7	7	0	6	6	1	5.35E-02	3	-4.9	1.13
2058.96602	1	9	6	4	8	5	3	5.20E-03	2	0.4	1.05
2059.84824	-6	9	6	3	8	5	4	1.58E-02	3	1.8	1.06
2066.5063	-27	6	4	2	5	1	5	5.08E-04	10	-3.0	
2070.56560	-12	9	2	7	8	1	8	4.85E-03	3	-3.2	1.16
2073.67185	0	11	5	6	10	4	7	2.65E-03	6	4.4	1.02
2078.71605	5	10	3	7	9	2	8	1.18E-03	3	-2.0	1.11
2081.22593	0	10	6	5	9	5	4	5.35E-03	4	1.7	1.04
2083.78420	-23	8	7	2	7	6	1	1.77E-02	3	0.5	1.13
2083.7902	3	8	7	1	7	6	2	5.93E-03	3	1.0	1.13
2084.0060	-9	10	6	4	9	5	5	1.83E-03	3	4.8	1.04
2086.4023	-5	11	4	7	10	3	8	1.83E-03	5	1.0	1.06
2092.7539	-4	9	3	7	8	0	8	1.41E-03	5	3.6	1.18
2095.02308	2	9	4	6	8	1	7	1.63E-03	7	4.4	1.17
2098.6171	58	6	5	2	5	2	3	{7.64E-04}			
2101.1459	0	11	6	6	10	5	5	5.25E-04	10	-0.9	
2108.4378	0	11	6	5	10	5	6	1.57E-03	6	0.3	1.03
2108.6191	-21	9	7	3	8	6	2	2.28E-03	3	3.5	1.13
2108.65504	3	9	7	2	8	6	3	6.58E-03	2	-0.3	1.13
2113.5416	-15	7	5	3	6	2	4	{3.93E-04}			
2117.5594	0	12	6	7	11	5	6	3.28E-04	15	-32.6	
2119.1006	15	7	4	3	6	1	6	7.28E-04	10	-9.9	
*2129.51583	0	8	8	1	7	7	0	9.00E-03	7	0.5	1.28
2129.6193	20	8	5	4	7	2	5	1.23E-03	4	-6.6	1.34
2132.90385	0	10	7	4	9	6	3	2.18E-03	4	-1.9	1.12
2133.0668	-15	10	7	3	9	6	4	6.83E-04	10	-8.0	
2134.2901	-32	10	2	8	9	1	9	4.62E-04	10	-6.2	
2140.3099	-8	10	4	7	9	1	8	1.68E-03	6	0.0	1.19
2144.2676	-24	11	3	8	10	2	9	8.01E-04	10	-2.8	1.15
2147.9495	-14	10	3	8	9	0	9	1.40E-03	4	6.9	1.21
2149.2352	-33	9	5	5	8	2	6	3.82E-04	10	6.1	
*2155.05680	-21	9	8	1	8	7	2	3.36E-03	10	2.0	1.29
2156.9656	0	11	7	4	10	6	5	6.95E-04	10	3.6	
2164.0268	30	7	5	2	6	2	5	3.89E-04	10	-2.7	
2174.4298	-63	10	5	6	9	2	7	6.77E-04	10	6.8	
*2180.2038	0	10	8	3	9	7	2	1.13E-03	10	3.6	
2196.1488	-39	11	2	9	10	1	10	3.73E-04	10	-8.3	
*2198.2787	0	9	9	0	8	8	1	1.05E-03	7	-5.4	
2205.2167	0	11	8	3	10	7	4	2.83E-04	15	-15.9	
*2224.1543	0	10	9	2	9	8	1	3.24E-04	15	-9.7	

[a] An asterisk denotes a doubled absorption, with the quantum assignment given for the stronger transition. The strength given represents the sum of the strengths of the two comparable transitions. o − c is the observed minus the computed line position in inverse centimeters times 10^5. The computed values are derived from energy levels given in Table 2. %s is the estimated uncertainty in the measured line strength given in percent. Line strengths given within braces are the computed values derived in this study; (o − c)% is the observed minus the computed line strength in percent. R is the ratio of the computed line strength derived in this study to that given in Ref. 7.

$j = 8$ are those given by Flaud and Camy-Peyret,[13] and the next 11 terms ($j = 9$ to $j = 19$) were empirically derived and found to be necessary in the $H_2{}^{16}O$ analysis.[1] In the present analysis as many as 18 matrix elements ($j = 1$ to and including $j = 18$) were used. Several fitting schemes were tried in the $H_2{}^{16}O$ study, and the general one found to be most productive was to break the data into spectral intervals and to fit each set of data separately. This procedure was also found to be best in performing the analysis on the present data sets; the method that

Table 7. Line Positions (cm^{-1}) and Strengths (cm^{-2}/atm at 296 K) Observed in the (010)–(000) Band of $H_2{}^{18}O$[a]

Observed Position	o − c	Upper J	Upper K_a	Upper K_c	Lower J	Lower K_a	Lower K_c	Observed Strength	%s	(o − c)%	R
1009.5539	-4	10	1	10	11	2	9	5.10E-04	10	11.5	1.52
1016.2653	23	8	2	7	9	5	4	1.46E-04	15	-15.1	1.25
1053.6295	-7	7	3	4	8	6	3	1.37E-04	15	9.5	
1055.874	103	10	1	9	11	4	8	1.73E-04	10	-2.3	1.40
1061.67089	-41	9	0	9	10	3	8	1.45E-03	5	2.3	1.42
1069.01183	-1	9	1	9	10	2	8	5.50E-04	3	8.8	1.41
1084.12971	-10	10	2	9	11	3	8	7.32E-04	3	3.2	1.38
1098.7398	-22	9	2	7	10	5	6	5.40E-04	3	-13.7	1.25
1100.9788	-6	6	2	5	7	5	2	6.44E-04	8	7.9	1.15
1102.8337	-14	9	1	8	10	4	7	1.73E-03	3	3.9	1.31
1108.6768	-28	6	1	6	7	4	3	9.22E-04	15	11.7	1.21
1116.69930	-2	8	0	8	9	3	7	1.43E-03	3	3.4	1.33
1120.6148	-42	8	2	6	9	5	5	3.09E-04	10	-13.1	1.20
1129.86635	-1	8	1	8	9	2	7	4.69E-03	3	-0.3	1.32
1135.3393	-3	5	2	4	6	5	1	1.43E-04	15	-44.1	1.10
1137.67335	1	7	2	5	8	5	4	1.39E-03	3	2.7	1.16
1145.16522	0	9	2	8	10	3	7	9.25E-04	5	-0.7	1.28
1146.02626	-9	8	1	7	9	4	6	1.39E-03	4	-4.6	1.25
1152.0025	5	6	2	4	7	5	3	3.65E-04	15	-19.6	1.12
1162.7459	-10	5	1	5	6	4	2	5.00E-04	6	-6.7	1.16
1165.84597	-34	5	2	3	6	5	2	9.19E-04	3	-3.0	1.09
1165.90815	4	10	3	8	11	4	7	1.14E-03	4	-2.6	1.23
1165.9257	-14	4	2	3	5	5	0	3.47E-04	5	0.2	1.06
1170.03485	-3	7	0	7	8	3	6	1.08E-02	2	-0.5	1.26
1184.13804	0	7	1	6	8	4	5	8.88E-03	2	-1.3	1.19
1191.92087	1	7	1	7	8	2	6	5.03E-03	3	7.8	1.24
1205.07959	-2	8	2	7	9	3	6	1.07E-02	2	-0.3	1.20
1209.29393	-29	4	1	4	5	4	1	1.85E-03	4	-4.1	1.11
1211.430	21	8	1	8	8	4	5	1.81E-04	10	4.0	0.86
1216.19269	0	6	1	5	7	4	4	4.34E-03	3	-2.9	1.15
1217.9074	-11	9	3	7	10	4	6	1.85E-03	6	1.3	1.16
1219.64240	-1	10	4	7	11	5	6	1.74E-03	3	-3.8	1.12
1220.72679	-15	6	0	6	7	3	5	8.39E-03	2	1.9	1.19
1222.1611	-59	9	0	9	9	3	6	1.42E-04	10	-2.4	0.91
1222.9103	18	11	5	6	12	6	7	3.40E-04	10	-8.4	1.07
1234.9516	-6	10	5	6	11	6	5	1.48E-03	8	-2.6	1.04
1238.5082	-43	8	2	7	8	5	4	1.80E-04	10	-1.1	0.80
1239.0281	4	10	6	5	11	7	4	8.90E-04	5	1.8	0.97
1239.4807	35	10	6	4	11	7	5	3.37E-04	15	13.8	0.96
1241.2012	5	10	5	5	11	6	6	5.00E-04	5	-2.4	1.03
1242.24388	0	5	1	4	6	4	3	1.34E-02	2	-0.1	1.11
1244.78805	0	10	7	4	11	8	3	(4.15E-04)			0.88
1249.5898	-35	3	1	3	4	4	0	3.90E-04	4	1.3	1.07
1253.52209	-2	9	4	6	10	5	5	2.48E-03	3	-1.5	1.07
1253.92388	-17	6	1	6	7	2	5	3.93E-02	3	-2.8	1.17
1258.3019	-23	11	4	7	12	5	8	4.72E-04	5	-10.0	1.06
1259.9493	-1	9	5	5	10	6	4	2.00E-03	3	6.3	1.00
1261.57712	-29	7	2	6	8	3	5	1.32E-02	4	-0.9	1.14
1262.2615	-11	9	5	4	10	6	5	5.68E-03	2	0.5	0.99
1262.8249	7	9	6	4	10	7	3	1.09E-03	2	3.8	0.93
1262.94896	-3	9	6	3	10	7	4	3.14E-03	3	-0.2	0.93
1263.70927	-36	4	1	3	5	4	2	2.66E-03	3	-6.4	1.09
1263.72188	-19	8	3	6	9	4	5	2.32E-02	2	0.7	1.10
1265.18893	-7	10	4	6	11	5	7	7.10E-04	5	-1.2	1.05
1267.63985	-16	5	0	5	6	3	4	4.65E-02	3	0.8	1.14
*1268.8225	-25	9	7	2	10	8	3	2.06E-03	3	3.5	0.85
*1271.6429	-19	15	0	15	16	1	16	1.87E-04	15	-11.8	1.26
1272.1053	-46	6	2	5	6	5	2	3.18E-04	10	-3.6	0.85
1276.71900	13	9	4	5	10	5	6	8.26E-03	2	1.5	1.03
*1277.84852	-2	9	8	1	10	9	2	7.93E-04	5	-5.5	0.76
1280.5560	-43	8	0	8	8	3	5	3.53E-04	15	22.8	0.97
1282.75416	-28	3	1	2	4	4	1	2.93E-03	2	1.3	1.06
1282.80632	-1	8	4	5	9	5	4	2.56E-02	3	-4.2	1.03
1283.3436	-30	6	1	6	6	4	3	9.62E-04	4	4.6	0.93
1284.27381	9	8	5	4	9	6	3	1.78E-02	4	-3.5	0.96
1284.99010	1	8	5	3	9	6	4	6.20E-03	4	0.8	0.97
1286.82051	-5	8	6	3	9	7	2	9.55E-03	3	-6.0	0.89
1286.84734	2	8	6	2	9	7	3	3.52E-03	3	4.1	0.89
*1289.2779	-120	9	9	0	10	10	1	4.00E-04	15	19.3	
*1292.0969	-6	14	1	14	15	0	15	8.30E-04	3	-0.9	1.22
1292.94187	8	8	4	4	9	5	5	9.32E-03	2	1.9	1.02
*1292.98988	-6	8	7	2	9	8	1	6.21E-03	3	-3.2	0.82
*1302.20236	-10	8	8	1	9	9	0	2.71E-03	2	-0.5	0.74
1302.69582	-6	7	3	5	8	4	4	2.83E-02	3	2.5	1.06
1308.45835	-2	7	5	3	8	6	2	1.72E-02	3	-3.7	0.94
1308.63417	0	7	5	2	8	6	3	4.98E-02	3	-7.2	0.94
1309.25597	-4	7	4	4	8	5	3	2.66E-02	3	-1.4	1.00
1309.59105	0	4	0	4	5	3	3	2.19E-02	4	3.2	1.10
1310.3893	0	5	1	5	5	4	2	3.90E-04	10	2.0	0.95
1311.0384	-36	7	6	2	8	7	1	9.85E-03	4	1.0	0.87
1311.0419	-47	7	6	1	8	7	2	2.96E-02	4	1.2	0.87
1312.2392	-37	5	2	3	5	5	0	2.65E-04	10	-6.0	0.88
1312.4228	20	13	0	13	14	1	14	2.47E-03	6	7.1	1.18
1312.427	-1	13	1	13	14	0	14	8.35E-04	6	8.5	1.18
1312.63257	-1	6	2	5	7	3	4	1.41E-01	5	1.1	1.09
1312.94534	0	7	4	3	8	5	4	7.95E-02	6	-2.6	1.00
1313.1609	-1	11	3	8	12	4	9	9.60E-04	10	2.6	1.01
1313.69563	-3	5	1	5	6	2	4	3.98E-02	4	2.7	1.12
1316.32281	-12	10	3	7	11	4	8	1.11E-03	3	0.9	1.01
*1317.38665	-6	7	7	0	8	8	1	1.74E-02	3	-6.7	0.79
1320.25610	1	9	3	6	10	4	7	1.10E-02	2	0.3	1.02
1320.5438	1	13	2	11	14	3	12	1.70E-04	10	-6.7	1.04
1320.8371	-47	13	1	12	14	2	13	7.08E-04	15	15.0	1.09
1321.0034	2	13	2	12	14	1	13	1.91E-04	10	-5.3	1.09
1322.08418	4	9	1	8	9	4	5	1.15E-03	3	2.9	0.95
1322.20535	11	14	1	14	14	2	13	4.20E-04	5	-7.0	1.36
1322.2286	0	14	0	14	14	1	13	1.39E-04	10	-7.8	
1322.8780	-12	6	2	4	6	5	1	2.71E-04	10	6.9	0.87
1323.3407	0	13	3	11	14	2	12	(6.04E-05)			
1326.52471	2	8	3	5	9	4	6	1.19E-02	3	4.1	1.02
1331.4429	-69	4	1	4	4	4	1	7.00E-04	10	-0.9	0.95
1332.19116	-4	7	0	7	7	3	4	4.17E-03	3	5.2	1.01
1332.60880	-1	12	0	12	13	1	13	2.40E-03	4	-6.9	1.15
1332.61790	0	12	1	12	13	0	13	7.75E-03	3	0.4	1.15
1332.73470	-1	6	5	2	7	6	1	1.30E-01	5	-6.2	0.92
1332.76543	5	6	5	1	7	6	2	4.32E-02	4	-6.5	0.92
1332.83870	-3	7	2	5	7	5	2	1.17E-03	10	2.2	0.88
1334.31034	3	6	4	3	7	5	2	2.05E-01	4	-4.0	0.97
1334.6454	-33	12	2	10	13	3	11	2.17E-04	10	-6.7	1.01
1335.37556	-1	6	4	2	7	5	3	6.95E-02	3	-2.6	0.97
*1335.45793	0	6	6	1	7	7	0	9.20E-02	10	-9.3	0.85
1335.51770	0	6	3	4	7	4	3	2.34E-01	5	-5.3	1.03
1336.4214	0	7	3	4	8	4	5	1.01E-01	4	1.4	1.02
1338.3173	0	12	1	11	13	2	12	8.45E-04	15	14.4	1.06
1338.65168	-1	12	2	11	13	1	12	2.31E-03	7	5.9	1.06
1339.6677	-37	9	2	7	9	5	4	7.61E-04	7	-1.9	0.88
1339.8289	6	12	3	10	13	2	11	6.87E-04	5	-0.2	1.00
1343.2810	-4	13	1	13	13	2	12	5.90E-04	6	9.1	1.31
1343.32982	1	13	0	13	13	1	12	1.66E-03	3	2.6	1.32
1345.72526	-1	3	0	3	4	3	2	5.50E-02	4	1.4	1.07
1347.57582	-1	11	2	9	12	3	10	2.55E-03	4	4.7	0.99
1348.6881	9	12	4	9	13	3	10	2.18E-04	10	0.9	0.94
1350.75023	-1	6	3	3	7	4	4	8.45E-02	3	-4.2	1.01
1352.63885	1	11	0	11	12	1	12	2.27E-02	3	-4.0	1.12
1352.65880	1	11	1	11	12	0	12	7.87E-03	3	-0.1	1.12
1354.06658	4	8	1	7	8	4	4	1.36E-03	3	-1.3	0.97
1355.60274	0	11	1	10	12	2	11	7.40E-03	4	3.1	1.04
1356.28087	-3	11	2	10	12	1	11	2.51E-03	3	4.9	1.04
1356.84386	0	5	2	4	6	3	3	1.36E-01	3	-5.5	1.06
1357.0670	-12	11	3	9	12	2	10	8.17E-04	5	3.2	0.98
1357.1592	18	5	5	1	6	6	0	1.11E-01	6	4.2	0.89
1357.1615	-44	5	5	0	6	6	1	3.33E-01	6	4.2	0.90
1358.8059	-4	10	2	8	11	3	9	2.57E-03	3	0.1	0.99
1358.86029	-3	5	4	2	6	5	1	1.59E-01	4	-3.9	0.96
1359.08073	4	5	4	1	6	5	2	4.79E-01	6	-3.5	0.96
1363.95106	0	5	3	3	6	4	2	1.98E-01	3	-3.2	1.00
1364.24475	1	12	1	12	12	2	11	5.33E-03	3	0.4	1.27
1364.35012	5	12	0	12	12	1	11	1.88E-03	4	6.0	1.27
1367.99221	-1	9	2	7	10	3	8	2.32E-02	4	4.8	0.99
1368.92863	5	4	1	4	5	2	3	3.03E-01	5	-8.3	1.08

Table 7. *Continued*

Observed Position	o − c	Upper J	Upper K_a	Upper K_c	Lower J	Lower K_a	Lower K_c	Observed Strength	%s	(o − c)%	R
1369.42164	0	5	3	2	6	4	3	6.35E-01	6	1.5	1.00
1372.49561	-1	10	0	10	11	1	11	2.18E-02	3	-0.8	1.10
1372.53907	3	10	1	10	11	0	11	6.35E-02	3	-3.8	1.10
1372.57177	-1	10	1	9	11	2	10	7.35E-03	4	2.5	1.03
1373.1890	0	11	4	8	12	3	9	2.12E-04	15	-11.8	0.90
1373.94959	1	10	2	9	11	1	10	2.11E-02	3	-1.6	1.02
1374.87860	0	6	0	6	6	3	3	4.95E-03	3	1.1	1.03
1375.0745	6	7	1	6	7	4	3	9.90E-03	10	3.3	0.97
1375.44784	1	8	2	6	9	3	7	1.99E-02	3	3.1	1.00
1375.66455	1	10	3	8	11	2	9	7.44E-03	3	1.6	0.96
1376.23932	0	2	0	2	3	3	1	7.44E-03	3	7.0	1.05
1382.33616	3	7	2	5	8	3	6	1.42E-01	4	1.4	1.01
1383.32545	6	4	4	1	5	5	0	1.00E-00	5	-2.3	0.94
1383.35030	-2	4	4	0	5	5	1	3.44E-01	3	0.8	0.94
1385.07293	1	11	1	11	11	2	10	5.46E-03	3	2.6	1.22
1385.30126	4	11	0	11	11	1	10	1.66E-02	3	3.7	1.22
1385.5814	17	4	1	3	4	4	0	1.09E-03	5	3.6	0.96
1385.90105	-2	6	1	5	6	4	2	4.44E-03	3	3.5	0.97
1388.48389	-6	5	1	4	5	4	1	9.80E-03	10	4.3	0.96
1389.01607	1	9	1	8	10	2	9	5.67E-02	5	-2.8	1.02
1389.91036	-1	4	3	2	5	4	1	1.36E-00	3	4.4	0.99
1390.23100	1	6	2	4	7	3	5	1.05E-01	4	-0.6	1.02
1391.32592	1	4	3	1	5	4	2	4.20E-01	5	-3.7	0.99
1391.79875	1	9	2	8	10	1	9	1.98E-02	3	2.5	1.01
1392.15728	3	9	0	9	10	1	10	1.55E-01	5	-7.6	1.08
1392.25375	0	9	1	9	10	0	10	5.40E-02	4	-3.2	1.09
1393.88008	-2	4	2	3	5	3	2	1.09E-00	5	-1.8	1.03
1396.53209	0	9	3	7	10	2	8	6.84E-03	3	3.7	0.95
1400.0873	12	13	2	12	13	3	11	3.46E-04	10	-1.6	1.22
1400.54005	1	5	2	3	6	3	4	6.91E-01	3	2.5	1.02
1400.9436	-11	13	1	12	13	2	11	1.19E-03	5	11.4	1.21
1402.13700	4	10	4	7	11	3	8	2.21E-03	3	8.9	0.88
1404.59618	0	8	1	7	9	2	8	4.92E-02	5	3.5	1.01
1405.72605	2	10	1	10	10	2	9	4.31E-02	4	-2.0	1.18
1406.22128	-1	10	0	10	10	1	9	1.48E-02	3	0.7	1.19
1407.29376	-4	5	0	5	5	3	2	3.56E-02	3	-0.2	1.02
1410.11421	1	8	2	7	9	1	8	1.41E-01	4	0.4	1.00
1411.59153	5	8	0	8	9	1	9	1.20E-01	5	-6.5	1.07
1411.80823	0	8	1	8	9	0	9	3.78E-01	3	-1.6	1.07
1414.28465	1	4	2	2	5	3	3	4.52E-01	3	1.4	1.02
1414.78019	-1	3	3	1	4	4	0	8.14E-01	5	1.0	0.97
1414.98365	-2	3	3	0	4	4	1	2.43E-00	4	0.4	0.98
1417.76384	1	12	2	11	12	3	10	3.69E-03	4	-1.9	1.17
1417.80330	-1	3	1	3	4	2	2	3.00E-01	3	2.4	1.05
1418.86017	5	7	1	6	8	2	7	3.23E-01	5	3.7	1.01
1419.4577	33	12	1	11	12	2	10	{1.26E-03}			1.05
1420.72168	0	8	3	6	9	2	7	4.65E-02	6	2.2	0.94
1424.87420	1	3	2	2	4	3	1	7.65E-01	3	-0.6	1.01
1426.13134	3	9	1	9	9	2	8	3.67E-02	4	-0.5	1.15
1427.19627	-1	9	0	9	9	1	8	1.13E-01	3	1.3	1.15
1429.41122	3	7	2	6	8	1	7	1.02E-01	3	1.9	1.00
1429.48476	-4	4	0	4	4	3	1	1.58E-02	3	1.2	1.02
1430.74204	4	7	0	7	8	1	8	8.11E-01	3	1.7	1.06
1431.23090	1	7	1	7	8	0	8	2.69E-01	3	1.3	1.06
1431.49075	-1	6	1	5	7	2	6	2.07E-01	4	2.5	1.01
1431.99890	-10	3	2	1	4	3	2	2.40E-00	10	-1.6	1.01
1435.21968	11	11	2	10	11	3	9	4.20E-03	10	2.6	1.14
1435.35365	0	9	4	6	10	3	7	1.71E-03	4	5.0	0.86
1438.50196	1	11	1	10	11	2	9	1.24E-02	5	-1.6	1.14
1442.70975	-5	3	0	3	3	3	0	2.45E-02	3	-0.7	1.01
1442.82606	2	5	1	4	6	2	5	1.09E-00	2	2.8	1.02
1446.15185	-2	8	1	8	8	2	7	2.51E-01	2	-1.4	1.12
1447.2163	0	13	3	11	13	4	10	1.71E-04	15	-17.3	1.16
1448.39026	5	8	0	8	8	1	7	8.37E-02	4	-3.0	1.12
1448.91265	-1	7	3	5	8	2	6	2.97E-02	3	2.5	0.94
1449.50218	1	6	0	6	7	1	7	4.93E-01	3	-0.4	1.05
1450.48781	2	6	2	5	7	1	6	5.65E-01	4	2.2	1.00
1450.59909	-2	6	1	6	7	0	7	1.49E-00	3	0.6	1.05
1451.91149	6	2	2	1	3	3	0	4.00E-00	4	0.3	1.00
1452.20410	0	10	2	9	10	3	8	3.30E-02	7	-10.3	1.11
1453.34315	-1	2	2	0	3	3	1	1.39E-00	2	3.5	1.00
1454.08567	1	4	1	3	5	2	4	5.83E-01	3	3.1	1.02
1454.9466	8	13	2	11	13	3	10	6.15E-04	3	-4.8	1.17
1458.3308	2	10	1	9	10	2	8	{1.28E-02}			1.11
1459.23783	0	2	1	2	3	2	1	{2.04E-00}			1.03
1461.29602	-2	12	3	10	12	4	9	2.35E-03	5	2.3	1.13
1465.54540	-1	7	1	7	7	2	6	1.72E-01	3	-3.3	1.09
1466.77783	0	3	1	2	4	2	3	2.58E-00	3	2.4	1.02
1467.67644	3	5	0	5	6	1	6	2.49E-00	3	1.0	1.05
1468.34779	-4	9	2	8	9	3	7	3.37E-02	5	2.1	1.08
1470.04640	-1	7	0	7	7	1	6	5.43E-01	4	-1.7	1.09
1470.08731	2	5	1	5	6	0	6	8.25E-01	4	1.2	1.04
1471.62086	-1	8	4	5	9	3	6	1.07E-02	2	5.0	0.84
1472.3220	1	10	5	6	11	4	7	4.30E-04	10	-2.5	0.75
1474.2587	23	11	3	9	11	4	8	2.50E-03	8	-5.6	1.09
1474.27379	0	5	2	4	6	1	5	2.85E-01	3	1.5	0.99
1479.08373	-2	9	1	8	9	2	7	1.01E-01	6	-7.6	1.09
1480.76468	1	6	3	4	7	2	5	1.40E-01	4	2.6	0.92
1481.97745	-1	2	1	1	3	2	2	1.21E-00	4	4.2	1.02
1483.17147	5	8	2	7	8	3	6	2.41E-01	2	-0.1	1.05
1483.92606	0	6	1	6	6	2	5	1.01E-00	2	0.0	1.07
1484.97158	0	4	0	4	5	1	5	1.22E-00	4	1.5	1.04
1485.65439	-2	10	3	8	10	4	7	2.45E-02	5	-0.4	1.06
1490.04036	-5	4	1	4	5	0	5	3.60E-00	10	2.2	1.03
1492.30853	0	6	0	6	6	1	5	3.69E-01	3	1.5	1.07
1493.27694	0	1	1	1	2	2	0	1.32E-00	3	3.7	1.02
1493.86732	28	11	2	9	11	3	8	9.15E-03	3	-6.2	1.11
1495.08172	-1	9	3	7	9	4	6	2.25E-02	4	-0.3	1.03
1495.7939	18	10	1	10	9	2	7	2.81E-04	5	-3.7	0.67
1496.14424	-6	7	2	6	7	3	5	{1.73E-01}			1.02
1496.45438	6	11	4	8	11	5	7	{1.40E-03}			0.98
1500.15893	2	1	1	0	2	2	1	4.49E-00	6	-0.5	1.02
1500.28336	4	8	1	7	8	2	6	9.50E-02	5	-1.2	1.07
1500.76535	2	5	1	5	5	2	4	5.61E-01	6	-1.6	1.05
1500.95907	2	10	4	7	10	5	6	1.32E-02	3	2.1	0.96
1501.18836	3	3	0	3	4	1	4	4.64E-00	3	1.1	1.04
1501.24841	-1	4	2	3	5	1	4	1.04E-00	3	2.7	0.99
1502.1610	-29	12	5	8	12	6	7	5.44E-04	5	1.4	0.91
1502.28512	1	8	3	6	8	4	5	1.58E-01	4	-3.1	1.01
1503.5536	-13	11	5	7	11	6	6	6.09E-04	10	-0.1	0.88
1503.7036	-5	9	4	6	9	5	5	1.17E-02	3	1.7	0.94
1503.71550	-3	6	5	2	6	6	1	6.27E-02	3	-0.1	0.82
1503.74033	0	6	5	1	6	6	0	2.09E-02	4	-0.1	0.81
1503.75217	-5	7	5	3	7	6	2	1.74E-02	3	-1.5	0.82
1503.88728	1	7	5	2	7	6	1	5.36E-02	3	1.2	0.82
1503.90161	1	8	5	4	8	6	3	2.96E-02	4	-2.6	0.83
1504.06298	0	10	5	6	10	6	5	5.51E-03	4	1.2	0.86
1504.07313	-5	9	5	5	9	6	4	5.02E-03	3	7.3	0.84
1504.42307	0	8	5	3	8	6	2	1.06E-02	3	4.5	0.83
1505.04998	9	8	4	5	8	5	4	7.85E-02	4	-1.0	0.92
1505.29559	3	5	4	2	5	5	1	8.32E-02	5	-0.2	0.89
1505.43723	2	6	4	3	6	5	2	{2.36E-01}			0.89
1505.6603	-25	9	5	4	9	6	3	{1.40E-02}			0.84
1506.25128	4	6	4	2	6	5	1	7.70E-02	5	-2.8	0.90
1506.40037	0	10	6	5	10	7	4	2.05E-03	4	7.1	0.76
1506.4123	-3	9	6	4	9	7	3	1.50E-03	5	-3.7	0.75
1506.4452	-57	11	6	6	11	7	5	1.73E-04	15	-27.2	0.77
1506.50260	1	9	6	3	9	7	2	4.80E-03	10	2.7	0.74
1506.5233	55	8	6	3	8	7	2	9.05E-03	10	-1.5	0.74
1506.5438	18	8	6	2	8	7	1	3.00E-03	10	-2.1	0.74
*1506.7331	-110	7	6	1	7	7	0	1.61E-02	10	-1.6	0.74
1506.79947	-2	6	2	5	6	3	4	9.26E-01	10	-6.4	1.02
1507.23914	0	7	3	5	7	4	4	1.01E-01	10	-10.7	0.98
1508.0791	34	10	5	5	10	6	4	{1.81E-03}			0.86
1508.11076	3	7	4	3	7	5	2	1.47E-01	4	-4.5	0.91
1509.13352	0	7	4	4	8	3	5	6.73E-03	4	8.7	0.84
1510.18454	2	6	3	4	6	4	3	5.78E-01	4	-1.2	0.97
1511.02876	0	3	1	3	4	0	4	1.44E-00	3	1.7	1.03
1511.3165	55	9	5	5	10	4	6	4.04E-04	10	9.1	0.73
1511.59438	2	5	3	3	5	4	2	2.73E-01	8	1.0	0.96

(continued overleaf)

Table 7. *Continued*

Observed		Upper			Lower			Observed			
Position	o − c	J	K_a	K_c	J	K_a	K_c	Strength	%s	(o − c)%	R
1511.75400	0	8	4	4	8	5	3	2.68E-02	3	0.4	0.92
1512.05977	3	4	3	2	4	4	1	7.53E-01	3	-1.7	0.95
1512.2292	8	11	5	6	11	6	5	(1.84E-03)			0.88
1512.6425	36	10	7	4	10	8	3	6.48E-04	10	13.8	0.65
1512.6575	14	10	7	3	10	8	2	1.96E-04	10	4.2	0.65
1512.72401	0	10	2	8	10	3	7	1.07E-02	5	-6.1	1.09
*1513.0732	-76	9	7	2	9	8	1	1.80E-03	4	7.3	0.65
1513.19752	1	4	3	1	4	4	0	2.55E-01	4	-0.4	0.95
*1513.5405	9	8	7	2	8	8	1	2.70E-03	10	6.5	0.65
1514.66212	0	5	0	5	5	1	4	2.04E-00	3	1.0	1.06
1514.85770	1	5	2	4	5	3	3	5.30E-01	8	1.0	1.00
1514.90073	1	5	3	3	6	2	4	5.95E-02	5	1.7	0.93
1515.12329	-3	8	0	8	7	3	5	6.20E-04	10	-12.9	0.77
1515.46698	0	4	1	4	4	2	3	2.50E-00	5	-0.8	1.04
1515.66173	2	5	3	2	5	4	1	8.15E-01	3	-0.7	0.96
1516.76581	-3	2	0	2	3	1	3	(1.69E-00)			1.03
1517.64702	10	9	4	5	9	5	4	3.55E-02	7	0.4	0.94
1520.45862	0	6	3	3	6	4	2	1.95E-01	4	-3.4	0.97
1521.8187	25	9	1	9	8	2	6	3.25E-04	10	-7.9	0.75
*1523.3988	11	9	8	1	9	9	0	(3.13E-04)			0.57
1523.48215	2	3	2	2	3	3	1	5.84E-01	3	0.2	0.99
1525.28638	6	10	4	6	10	5	5	4.51E-03	3	0.0	0.96
1526.35813	2	7	0	7	6	3	4	5.10E-03	4	5.2	0.83
1527.35780	0	7	3	4	7	4	3	(3.62E-01)			0.98
1527.50688	2	3	1	3	3	2	2	1.04E-00	3	1.9	1.03
1528.09273	-1	4	0	4	3	3	1	1.98E-03	5	1.1	0.93
1528.48266	5	9	2	7	9	3	6	9.85E-02	5	-10.3	1.07
1528.98357	4	3	2	1	3	3	0	1.86E-00	3	1.8	1.00
1530.77349	-1	3	2	2	4	1	3	3.10E-01	5	2.4	0.99
1532.8837	10	11	4	7	11	5	6	4.54E-03	4	1.1	0.98
1532.8923	-13	6	0	6	5	3	3	2.95E-03	10	3.1	0.87
1533.05735	-1	1	0	1	2	1	2	4.95E-00	4	-0.6	1.03
1533.5444	3	6	1	5	5	4	2	7.34E-04	15	-14.8	0.81
1533.70045	1	2	1	2	3	0	3	3.75E-00	10	-5.5	1.03
1533.7307	-32	5	0	5	4	3	2	9.11E-03	15	-11.4	0.90
1534.17842	3	4	2	2	4	3	1	7.52E-01	3	-0.1	1.00
1534.56485	-3	8	3	5	8	4	4	6.15E-02	3	0.0	1.00
1535.38414	3	4	0	4	4	1	3	1.16E-00	5	-1.2	1.04
1535.52991	1	11	3	8	11	4	7	7.85E-03	5	-1.9	1.05
1536.56134	3	2	1	2	2	2	1	2.73E-00	4	3.7	1.02
1536.85076	3	6	1	5	6	2	4	5.41E-01	3	1.1	1.04
1539.30493	-1	8	2	6	8	3	5	9.45E-02	4	-7.5	1.06
1539.50636	-3	9	3	6	9	4	5	7.43E-02	5	-5.2	1.02
1540.19388	5	5	2	3	5	3	2	(1.95E-00)			1.01
1544.38263	-2	6	2	4	6	3	3	4.44E-01	5	0.0	1.02
1544.49245	0	7	2	5	7	3	4	7.07E-01	3	-0.7	1.04
1545.96405	2	6	4	3	7	3	4	3.13E-02	4	7.8	0.84
1545.9709	-17	9	4	5	10	3	8	1.56E-03	15	-21.6	0.73
1547.61322	6	8	1	8	7	2	5	3.75E-03	5	1.4	0.82
1547.7744	0	8	4	4	9	3	7	1.63E-03	4	8.0	0.77
1548.11830	-1	5	1	4	5	2	3	3.09E-00	3	0.1	1.03
1549.54472	-1	4	3	2	5	2	3	1.73E-01	6	-2.9	0.93
1549.74125	-1	7	1	6	6	4	3	2.90E-03	10	-8.3	0.78
1550.2664	-52	9	5	4	10	4	7	(9.16E-04)			0.70
1551.52702	0	0	0	0	1	1	1	1.33E-00	6	-4.4	1.04
1551.95028	3	2	1	1	2	2	0	1.23E-00	5	-1.1	1.01
1552.13400	2	3	0	3	3	1	2	5.50E-00	6	-0.7	1.04
1553.79442	3	4	1	3	4	2	2	1.55E-00	3	-1.1	1.02
1554.59874	1	3	1	2	3	2	1	(5.23E-00)			1.02
1558.13265	3	1	1	1	2	0	2	7.60E-01	4	-3.4	1.03
1560.64717	-1	9	1	8	8	4	5	1.13E-03	5	-0.3	0.71
1561.33558	-3	2	2	1	3	1	2	5.23E-01	4	1.7	1.00
1561.9120	37	9	2	7	8	5	4	3.00E-04	10	-1.0	0.66
1563.54528	3	2	0	2	2	1	1	2.38E-00	4	1.2	1.04
1566.04832	1	6	3	3	7	2	6	1.13E-02	3	8.5	0.88
1569.40712	4	8	5	3	9	4	6	8.05E-04	3	3.8	0.72
1570.00380	0	5	3	2	6	2	5	6.72E-02	10	-10.7	0.91
1570.02258	0	1	0	1	1	1	0	6.35E-00	4	1.5	1.03
1570.90538	0	7	1	7	6	2	4	4.38E-03	4	4.1	0.88
1571.14345	-3	7	3	4	8	2	7	9.70E-03	5	3.9	0.83
1573.60412	1	6	4	2	7	3	5	8.87E-03	2	8.6	0.83
1580.36482	-3	5	4	2	6	3	3	1.34E-02	2	10.3	0.86
1581.48260	3	7	5	3	8	4	4	1.66E-03	6	5.7	0.75
1581.70193	-1	4	3	1	5	2	4	4.05E-02	3	3.3	0.93
1582.99336	0	3	3	1	4	2	2	4.03E-02	4	2.5	0.95
1585.09463	11	8	3	5	9	2	8	7.80E-04	5	4.6	0.78
1587.46208	1	3	2	1	4	1	4	1.63E-01	5	1.6	0.99
1589.21839	6	6	1	6	5	2	3	4.18E-02	2	1.6	0.93
1589.66515	-2	4	2	2	5	1	5	2.56E-02	3	6.6	0.97
1591.3426	-18	9	6	3	10	5	6	3.31E-04	10	7.8	0.66
1591.42601	1	7	5	2	8	4	5	4.50E-03	6	-2.9	0.75
1593.77444	2	5	4	1	6	3	4	3.60E-02	4	4.5	0.86
1593.86968	0	2	2	0	3	1	3	6.80E-02	5	5.5	1.00
1597.47966	1	3	1	3	2	2	0	1.01E-01	4	-0.1	1.00
1599.00708	2	3	3	0	4	2	3	1.03E-01	8	2.4	0.96
1600.47406	0	5	1	5	4	2	2	4.02E-02	3	1.3	0.97
1600.57644	0	5	2	3	6	1	6	2.52E-02	6	5.7	0.94
1603.28789	1	4	1	4	3	2	1	2.41E-01	4	-7.2	0.99
1606.43830	-1	9	3	6	10	2	9	4.50E-04	5	-5.2	0.72
1609.87978	-3	1	1	0	1	0	1	5.80E-00	6	2.0	1.04
1611.27964	-1	4	4	1	5	3	2	3.04E-02	3	5.8	0.88
1612.5890	20	8	6	3	9	5	4	6.43E-04	5	-2.8	0.68
1612.69450	1	10	2	9	9	3	6	1.09E-03	3	-4.5	0.74
1615.03900	1	6	5	1	7	4	4	2.42E-03	4	5.9	0.78
1615.20356	-14	8	6	2	9	5	5	2.43E-04	10	9.7	0.68
1616.43345	1	4	4	0	5	3	3	1.00E-02	3	5.6	0.88
1616.80590	-3	2	1	1	2	0	2	(2.01E-00)			1.04
1617.30185	0	4	2	3	3	3	0	1.85E-01	4	-8.2	0.95
1619.00620	-2	6	2	4	7	1	7	2.37E-03	4	3.1	0.90
1621.58525	0	2	0	2	1	1	1	1.00E-00	4	-2.5	1.05
1628.06004	-2	1	1	1	0	0	0	1.45E-00	3	-0.3	1.05
1629.06133	-1	3	1	2	3	0	3	4.35E-00	3	0.0	1.06
1631.92222	1	3	1	2	2	2	1	8.40E-01	5	3.9	1.01
1632.20498	4	9	2	8	8	3	5	1.69E-03	4	0.3	0.80
1632.78635	2	4	2	2	3	3	1	8.15E-02	3	3.4	0.95
1633.46595	-1	5	3	3	4	4	0	2.53E-02	3	6.4	0.87
1634.75145	1	5	2	4	4	3	1	8.21E-02	5	0.3	0.93
1637.81105	-3	5	3	2	4	4	1	7.40E-02	4	2.1	0.88
1638.1663	24	5	5	1	6	4	2	2.03E-03	3	0.3	0.82
1638.40765	-6	3	2	1	3	1	2	3.97E-00	3	-0.3	1.04
1638.5103	-75	7	6	2	8	5	3	(3.59E-04)			0.72
1639.32304	-3	5	5	0	6	4	3	6.45E-03	6	6.0	0.82
1639.35209	11	7	6	1	8	5	4	1.10E-03	5	1.7	0.73
1640.07771	1	4	2	2	4	1	3	1.17E-00	3	1.0	1.04
1640.64913	4	2	2	0	2	1	1	9.81E-01	5	2.3	1.04
1643.04321	-4	7	2	5	8	1	8	1.77E-03	5	-7.1	0.84
1645.32775	1	8	2	7	7	3	4	2.06E-02	2	1.6	0.85
1646.0282	-4	3	0	3	2	1	2	(5.74E-00)			1.04
1646.28217	-4	2	1	2	1	0	1	5.84E-00	3	-2.6	1.05
1646.45327	-1	6	2	5	5	3	2	1.61E-01	3	0.9	0.91
1647.01982	-2	4	1	3	4	0	4	8.10E-01	3	-1.9	1.07
1647.56215	0	5	2	3	5	1	4	2.16E-00	3	0.5	1.05
1650.29595	-1	7	2	6	6	3	3	2.30E-02	2	3.3	0.89
1651.83045	-2	6	4	3	5	5	0	2.03E-02	2	7.6	0.79
1652.68644	-4	6	4	2	5	5	1	6.67E-03	5	6.0	0.79
1655.22986	-1	2	2	1	2	1	2	1.95E-00	3	-1.3	1.04
1656.42459	0	6	3	4	5	4	1	9.16E-02	4	0.2	0.86
1661.81262	4	6	2	4	6	1	5	3.30E-01	4	-2.5	1.07
1662.33533	0	3	1	3	2	0	2	2.42E-00	4	1.3	1.06
1663.2408	-30	6	6	1	7	5	2	1.01E-03	5	-5.8	0.78
1663.2858	-22	8	7	2	9	6	3	1.01E-04	15	-43.3	0.73
1663.49793	-1	4	1	3	3	2	2	4.98E-01	4	-1.0	1.01
1664.00862	-3	3	2	2	3	1	3	7.35E-01	4	1.3	1.05
1666.63105	0	5	2	3	4	3	2	3.79E-01	5	1.7	0.94
1668.10191	-1	6	3	3	5	4	2	3.30E-02	3	1.7	0.86
1668.61926	0	4	0	4	3	1	3	2.31E-00	3	-1.5	1.05
1669.23013	-1	5	1	4	5	0	5	1.25E-00	5	-1.5	1.09
1670.65664	8	4	3	2	5	0	5	6.27E-03	3	-3.9	0.97
1671.2926	25	5	3	3	6	0	6	1.49E-03	4	-11.8	0.93
1671.40825	-3	6	3	3	6	2	4	(2.71E-01)			1.05

Table 7. *Continued*

Observed		Upper			Lower			Observed			
Position	o − c	J	K_a	K_c	J	K_a	K_c	Strength	%s	(o − c)%	R
1672.60478	1	7	3	4	7	2	5	4.20E-01	6	-2.3	1.07
1674.72708	-9	7	5	3	6	6	0	1.37E-03	4	3.3	0.72
1674.86810	1	7	5	2	6	6	1	4.10E-03	4	3.0	0.72
1675.29604	-3	5	3	2	5	2	3	1.14E-00	4	-6.4	1.05
1675.78040	1	4	2	3	4	1	4	1.62E-00	5	-3.0	1.07
1676.2190	19	3	3	1	4	0	4	1.42E-03	6	1.8	0.99
1676.34746	-8	7	4	4	6	5	1	7.80E-03	5	3.0	0.78
1676.6554	-6	8	4	5	9	1	8	4.31E-04	10	-17.5	0.74
1676.94755	3	7	3	5	6	4	2	2.36E-02	3	4.5	0.84
1676.9671	-20	7	4	4	8	1	7	3.45E-04	10	-10.6	0.80
1677.43977	4	6	3	4	7	0	7	2.25E-03	5	-16.5	0.89
1677.75049	0	4	1	4	3	0	3	7.38E-00	4	-2.0	1.06
1679.23765	2	7	4	3	6	5	2	2.35E-02	3	2.7	0.78
1680.78166	0	8	3	5	8	2	6	5.55E-02	6	-4.7	1.10
1681.41066	-1	4	3	1	4	2	2	4.69E-01	5	-1.0	1.04
1682.34766	0	7	2	5	7	1	6	3.93E-01	3	-2.4	1.09
1683.8193	6	6	4	3	7	1	6	1.48E-03	10	-20.0	0.86
1686.82798	2	3	3	0	3	2	1	1.16E-00	4	-1.6	1.03
1688.2226	-9	7	3	5	8	0	8	2.81E-04	15	-29.8	0.84
1689.19411	3	5	0	5	4	1	4	6.50E-00	3	-2.8	1.06
1690.23818	-4	5	2	4	5	1	5	3.21E-01	4	-8.3	1.09
1692.19506	-3	2	2	1	1	1	0	4.29E-00	3	-4.2	1.05
1692.69691	0	3	3	1	3	2	2	3.70E-01	6	-1.5	1.03
1693.22152	1	8	3	6	7	4	3	3.19E-02	3	-8.4	0.82
1693.24234	-2	6	1	5	6	0	6	2.01E-01	3	-2.4	1.11
1693.69951	0	5	1	5	4	0	4	2.20E-00	4	-3.5	1.07
1694.65679	8	5	1	4	4	2	3	1.80E-00	4	-0.2	1.01
1696.0831	-3	4	3	2	4	2	3	1.19E-00	4	-4.9	1.04
1696.50602	2	9	3	6	9	2	7	5.35E-02	4	-6.7	1.14
1697.7948	2	5	4	2	6	1	5	5.00E-04	6	-12.2	0.91
1698.0918	10	11	3	9	10	4	6	2.76E-04	10	8.2	0.73
1698.68905	-4	2	2	0	1	1	1	1.24E-00	6	-1.2	1.06
1699.1548	10	8	5	4	7	6	1	4.63E-03	3	5.4	0.70
1699.7170	8	8	5	3	7	6	2	1.56E-03	4	6.4	0.70
1700.21526	-2	8	4	5	7	5	2	1.63E-02	5	-2.3	0.78
1701.97036	-3	5	3	3	5	2	4	3.04E-01	3	0.1	1.02
1702.02464	2	7	3	4	6	4	3	8.01E-02	3	-1.8	0.86
1702.2141	-48	8	6	3	7	7	0	7.30E-04	10	5.6	0.65
1702.2357	6	8	6	2	7	7	1	{2.29E-04}			0.65
1702.39649	1	6	2	4	5	3	3	1.32E-01	4	5.6	0.93
1703.12193	1	9	3	7	8	4	4	4.41E-03	4	2.8	0.80
1704.9048	9	10	3	8	9	4	5	3.62E-03	3	3.6	0.76
1705.131	100	8	5	4	9	2	7	1.34E-04	10	0.8	0.61
1706.46142	-4	9	4	5	9	3	6	3.50E-02	6	-4.4	1.00
1706.83588	-1	6	2	5	6	1	6	5.42E-01	3	-0.2	1.07
1707.11787	1	10	4	6	10	3	7	3.99E-03	5	-3.9	1.01
1707.13870	-2	8	2	6	8	1	7	4.68E-02	5	2.2	1.06
1707.96979	-7	8	4	4	7	5	3	6.05E-03	4	5.5	0.78
1708.27296	0	6	0	6	5	1	5	1.70E-00	3	0.9	1.01
1710.33015	-1	6	1	6	5	0	5	5.14E-00	3	0.8	1.02
1710.76665	-3	6	3	4	6	2	5	5.27E-01	3	-1.4	1.03
1710.78808	2	3	2	2	2	1	1	1.30E-00	5	1.2	1.02
1711.63141	-10	8	4	4	8	3	5	2.97E-02	3	2.0	1.00
1715.37815	0	11	4	7	11	3	8	3.22E-03	4	-5.9	1.03
1716.99645	-2	7	1	6	7	0	7	2.60E-01	5	-3.5	1.10
1718.6476	-37	4	4	1	5	1	4	{6.41E-04}			0.90
1718.78077	3	10	3	7	10	2	8	{4.82E-03}			1.07
1719.76442	-3	7	4	3	7	3	4	1.77E-01	4	0.9	1.00
1722.5159	4	9	4	6	8	5	3	2.85E-03	4	-2.6	0.76
1722.53724	3	7	3	5	7	2	6	8.67E-02	6	-0.5	1.05
1723.5065	34	9	5	5	8	6	2	{9.89E-04}			0.70
1723.92043	3	6	1	5	5	2	4	5.45E-01	5	1.9	0.98
1724.91955	2	7	2	6	7	1	7	9.10E-02	5	5.3	1.09
1725.28846	3	9	5	4	8	6	3	3.20E-03	6	6.7	0.70
1726.1086	-3	9	6	4	8	7	1	2.72E-04	15	16.0	0.64
1726.2045	-28	9	6	3	8	7	2	7.00E-04	15	1.7	0.64
1726.39450	-1	7	0	7	6	1	6	3.40E-00	10	-2.4	1.01
1726.72603	0	4	2	3	3	1	2	3.44E-00	10	6.0	1.02
1727.29701	0	7	1	7	6	0	6	1.20E-00	10	3.0	1.01
1727.75578	1	6	4	2	6	3	3	9.80E-02	3	-2.3	1.00
1732.30196	-1	3	2	1	2	1	2	2.21E-00	10	0.4	1.04
1733.4283	9	5	4	1	5	3	2	{4.22E-01}			1.00
1733.5172	0	9	2	7	9	1	8	4.29E-02	10	-7.7	1.09
1736.32722	3	4	4	0	4	3	1	1.37E-01	4	0.0	1.00
1737.00724	5	8	3	6	8	2	7	1.12E-01	6	1.4	1.06
1737.71684	-3	4	4	1	4	3	2	3.99E-01	5	-2.8	1.00
1738.37868	0	5	4	2	5	3	3	1.38E-01	5	-1.4	1.00
1738.65942	6	7	2	5	6	3	4	2.80E-01	6	-7.4	0.93
1739.10819	5	8	3	5	7	4	4	1.87E-02	3	4.8	0.86
1739.5934	5	8	1	7	8	0	8	3.86E-02	3	1.7	1.12
1739.89030	-18	9	4	5	8	5	4	{9.50E-03}			0.77
1740.13095	1	6	4	3	6	3	4	2.76E-01	5	-5.3	1.01
1740.65079	4	5	2	4	4	1	3	8.65E-01	5	0.9	1.01
1741.88703	-7	10	4	7	9	5	4	3.57E-03	4	0.5	0.74
1743.70047	6	7	4	4	7	3	5	5.20E-02	7	-2.5	1.02
1743.87856	2	8	2	7	8	1	8	1.04E-01	10	-7.2	1.12
1743.89863	8	8	0	8	7	1	7	7.00E-01	10	-1.3	1.01
1744.28818	-4	8	1	8	7	0	7	2.10E-00	4	-1.4	1.01
1745.28635	2	11	3	8	11	2	9	3.65E-03	4	-1.4	1.13
1747.46192	0	10	5	6	9	6	3	1.45E-03	5	-0.8	0.69
1749.59933	-12	11	5	6	11	4	7	1.70E-03	5	-0.4	1.00
1749.71270	2	8	4	5	8	3	6	7.40E-02	5	1.3	1.04
1749.9540	3	10	6	5	9	7	2	4.00E-04	10	-3.0	0.62
1750.32354	12	7	1	6	6	2	5	1.22E-00	5	3.3	0.98
1752.2027	7	10	5	5	9	6	4	4.70E-04	5	-5.1	0.69
1753.65155	-1	9	3	7	9	2	8	1.44E-02	3	4.4	1.10
1753.82161	1	6	2	5	5	1	4	1.98E-00	5	4.3	1.00
1756.5512	-44	11	4	8	10	5	5	3.47E-04	10	-6.6	0.72
1758.53640	14	9	4	6	9	3	7	9.43E-03	5	-0.4	1.06
1759.35751	-2	10	2	8	10	1	9	5.20E-03	5	5.4	1.14
1759.44540	0	10	5	5	10	4	6	1.88E-03	4	8.3	1.00
1760.96064	2	9	0	9	8	1	8	1.20E-00	5	3.1	1.01
1761.02562	0	9	1	8	9	0	9	4.39E-02	4	-1.2	1.16
1761.12845	-3	9	1	9	8	0	8	3.66E-01	4	-5.8	1.02
1761.29055	-2	3	3	0	3	0	3	2.41E-02	3	4.2	1.06
1762.66969	-1	3	3	1	2	2	0	1.19E-00	4	-0.9	1.03
1763.23996	-3	9	2	8	9	1	9	1.50E-02	3	2.2	1.16
1764.15144	0	3	3	0	2	2	1	3.49E-00	6	-2.2	1.03
1764.6007	-30	12	4	9	11	5	6	2.82E-04	10	5.3	0.68
1767.72589	0	7	2	6	6	1	5	3.95E-01	4	-6.6	0.99
1769.51724	2	9	5	4	9	4	5	1.46E-02	3	4.9	0.99
1770.21125	0	10	4	7	10	3	8	9.80E-03	5	2.0	1.10
1770.4313	-4	11	5	7	10	6	4	1.65E-04	15	-15.0	0.67
1771.83662	-1	10	3	8	10	2	9	1.43E-02	5	2.7	1.14
1773.31282	-3	4	2	2	3	1	3	3.28E-01	6	-4.7	1.06
1773.87186	3	8	2	6	7	3	5	6.45E-02	4	-4.3	0.93
1773.90783	-4	8	1	7	7	2	6	2.32E-01	6	-4.2	0.98
1774.63615	3	4	3	1	4	0	4	1.48E-02	5	5.0	1.07
1775.46767	-19	10	4	6	9	5	5	1.39E-03	7	-4.1	0.77
1777.44723	-4	8	5	3	8	4	4	1.12E-02	5	3.1	0.99
1777.66259	5	10	0	10	9	1	9	1.93E-01	6	1.1	1.02
1777.73555	-4	10	1	10	9	0	9	6.00E-01	8	4.6	1.02
1778.06946	3	9	3	6	8	4	5	2.93E-02	3	-1.2	0.85
1781.34045	1	11	5	6	10	6	5	5.83E-04	4	-1.5	0.68
1781.57268	-1	10	1	9	10	0	10	5.65E-03	4	5.7	1.21
1782.36240	0	7	5	2	7	4	3	6.42E-02	3	-1.0	0.98
1782.69001	-4	10	2	9	10	1	10	1.62E-02	3	1.6	1.21
1783.18290	-5	8	2	7	7	1	6	7.60E-01	5	1.6	0.98
1783.68680	-1	11	2	9	11	1	10	4.58E-03	3	3.8	1.19
1783.90403	0	4	3	2	3	2	1	2.37E-00	4	-2.8	1.03
1784.4649	-21	11	4	8	11	3	9	9.57E-04	4	-0.2	1.15
1784.74734	-3	6	5	1	6	4	2	3.50E-02	4	1.3	0.98
1785.56316	2	5	5	0	5	4	1	1.11E-01	4	-1.2	0.97
1785.80938	2	5	5	1	5	4	2	3.68E-02	4	-1.8	0.98
1785.87666	0	6	5	2	6	4	3	1.01E-01	3	-2.6	0.99
1786.02587	4	7	5	3	7	4	4	2.24E-02	3	3.7	0.99
1786.69342	-1	8	5	4	8	4	5	3.34E-02	3	3.2	1.00
1788.49024	7	9	5	5	9	4	6	4.55E-03	4	0.7	1.02
1791.11418	-4	4	3	1	3	2	2	8.00E-01	10	4.0	1.03
1791.4805	21	12	5	8	11	6	5	1.69E-04	10	-6.3	0.65

(continued overleaf)

Table 7. *Continued*

Observed Position	o − c	Upper J	Upper K_a	Upper K_c	Lower J	Lower K_a	Lower K_c	Observed Strength	%s	(o − c)%	R
1792.06828	-1	10	5	6	10	4	7	4.99E-03	4	2.7	1.04
1794.04164	-5	11	0	11	10	1	10	2.40E-01	4	-6.1	1.02
1794.07382	-1	11	1	11	10	0	10	8.00E-02	3	-6.1	1.02
1795.36923	-3	9	1	8	8	2	7	3.50E-01	10	-9.5	0.97
1796.40789	-1	5	3	2	5	0	5	3.28E-02	3	1.4	1.09
1797.9646	-15	11	5	7	11	4	8	5.02E-04	3	-0.2	1.07
1800.03874	2	9	2	8	8	1	7	1.30E-01	5	0.0	0.97
1800.6226	-7	13	3	10	13	2	11	1.93E-04	10	-6.5	1.29
1800.8043	-4	12	4	9	12	3	10	7.69E-04	4	-0.6	1.22
1801.48699	-6	11	1	10	11	0	11	5.27E-03	5	-1.1	1.27
1801.67911	-1	5	3	3	4	2	2	5.30E-01	5	4.2	1.02
1802.04537	-12	11	2	10	11	1	11	1.92E-03	4	8.0	1.27
1806.57446	4	9	2	7	8	3	6	1.10E-01	4	-3.9	0.92
1810.1146	-6	12	0	12	11	1	11	3.43E-02	5	0.0	1.03
1810.12904	-1	12	1	12	11	0	11	9.66E-02	4	-6.4	1.03
1810.52225	0	12	3	10	12	2	11	1.10E-03	10	-9.2	1.28
1814.20025	1	11	4	7	10	5	6	1.71E-03	5	0.2	0.76
1815.45026	1	10	1	9	9	2	8	6.11E-02	3	1.9	0.97
1816.05896	1	6	3	4	5	2	3	8.80E-01	3	-2.0	1.01
1817.33040	2	10	3	7	9	4	6	4.80E-03	3	0.6	0.85
1817.72908	0	10	2	9	9	1	8	1.80E-01	3	-0.5	0.97
1820.93335	-5	12	1	11	12	0	12	5.41E-04	5	-1.2	1.35
1821.21245	2	12	2	11	12	1	12	1.57E-03	4	-4.4	1.35
1821.83449	2	5	3	2	4	2	3	1.24E-00	3	-0.4	1.03
1822.09411	0	5	2	3	4	1	4	4.07E-01	2	0.7	1.07
1825.89055	0	13	0	13	12	1	12	3.88E-02	4	2.7	1.03
1825.89715	1	13	1	13	12	0	12	1.25E-02	6	-0.7	1.03
1827.52540	2	3	3	1	2	0	2	8.56E-03	4	6.5	1.08
1827.79994	3	6	3	3	6	0	6	4.88E-03	3	4.2	1.13
1827.89720	2	7	3	5	6	2	4	1.66E-01	4	-1.0	0.99
1828.47633	4	10	6	4	10	5	5	5.97E-04	6	-4.3	0.99
1832.27081	-2	9	6	3	9	5	4	(4.91E-03)			0.97
1834.01601	10	8	6	2	8	5	3	3.68E-03	4	0.4	0.97
1834.32983	0	6	6	0	6	5	1	8.00E-03	6	0.8	0.96
1834.36790	-10	6	6	1	6	5	2	2.35E-02	6	-1.3	0.95
1834.51735	-2	7	6	1	7	5	2	2.04E-02	3	3.8	0.96
1834.67409	5	11	1	10	10	2	9	7.00E-02	10	-6.9	0.96
1834.70137	-3	4	4	1	3	3	0	1.96E-00	3	-0.5	1.03
1834.72696	5	7	6	2	7	5	3	6.60E-03	5	0.8	0.96
1834.7686	-11	9	6	4	9	5	5	1.64E-03	10	-0.3	0.98
1834.7944	24	10	6	5	10	5	6	1.72E-03	10	-8.4	1.00
1834.83240	4	8	6	3	8	5	4	1.06E-02	3	-3.6	0.97
1834.93511	-2	4	4	0	3	3	1	6.45E-01	3	-1.8	1.02
1835.3444	1	11	6	6	11	5	7	2.15E-04	10	5.3	1.02
1835.77119	3	11	2	10	10	1	9	2.40E-02	4	-4.4	0.96
1835.90665	3	10	2	8	9	3	7	1.83E-02	5	-0.1	0.92
1838.46845	-3	8	3	6	7	2	5	2.60E-01	4	-2.7	0.98
1840.0103	2	13	1	12	13	0	13	4.50E-04	10	-4.4	1.45
1840.1508	12	13	2	12	13	1	13	1.40E-04	15	-12.0	
1840.79649	-4	5	4	1	5	1	4	8.80E-03	4	1.3	1.08
*1841.37790	-5	14	1	14	13	0	13	1.70E-02	6	1.1	1.04
1842.22650	0	4	4	0	4	1	3	1.03E-03	10	3.9	1.08
1845.18565	-5	6	4	2	6	1	5	3.90E-03	5	2.0	1.09
1849.33869	-1	9	3	7	8	2	6	4.45E-02	3	1.3	0.96
1853.34753	0	12	1	11	11	2	10	9.63E-03	3	2.5	0.96
1853.87477	-4	12	2	11	11	1	10	2.87E-02	4	1.7	0.96
1855.27617	-3	11	3	8	10	4	7	6.25E-03	5	2.9	0.85
*1856.57517	18	15	0	15	14	1	14	5.20E-03	4	1.7	1.04
1857.61967	1	7	4	3	7	1	6	8.45E-03	3	1.3	1.12
1858.27243	0	5	4	2	4	3	1	3.70E-01	5	-5.9	1.02
1858.36656	-8	4	3	2	3	0	3	6.30E-02	5	-0.2	1.09
1858.47795	0	6	3	3	5	2	4	1.88E-01	3	4.3	1.04
1859.86542	-1	5	4	1	4	3	2	1.15E-00	4	-2.0	1.02
1861.90428	-4	10	3	8	9	2	7	5.82E-02	5	-1.3	0.94
1861.94135	2	11	2	9	10	3	8	2.28E-02	5	0.3	0.91
1869.2799	7	7	3	4	7	0	7	(4.04E-03)			1.18
*1871.49483	0	16	1	16	15	0	15	1.48E-03	3	4.1	1.05
1871.6372	8	13	1	12	12	2	11	1.04E-02	3	8.4	0.95
1871.89192	-2	13	2	12	12	1	11	3.36E-03	2	5.2	0.95
1876.71628	0	11	3	9	10	2	8	8.00E-03	5	2.0	0.92
1877.77698	-3	6	2	4	5	1	5	4.92E-02	3	2.8	1.09
1879.46534	5	8	4	4	8	1	7	1.27E-03	3	3.2	1.17
1879.78473	0	6	4	3	5	3	2	6.28E-01	2	-0.1	1.02
1882.0134	10	7	7	0	7	6	1	4.10E-03	6	2.8	0.95
1882.0187	-5	7	7	1	7	6	2	1.36E-03	6	2.3	0.95
1882.8791	-18	8	7	1	8	6	2	1.03E-03	4	4.8	0.95
1882.9139	0	8	7	2	8	6	3	3.06E-03	4	3.8	0.95
1883.2411	33	10	7	3	10	6	4	2.09E-04	10	5.0	0.97
1883.3701	6	9	7	2	9	6	3	1.45E-03	6	-1.9	0.96
1883.5267	33	9	7	3	9	6	4	5.21E-04	10	5.6	0.96
1883.79047	-2	10	7	4	10	6	5	5.90E-04	5	-1.1	0.97
1885.38916	0	12	2	10	11	3	9	2.83E-03	5	3.2	0.90
1885.76963	3	6	4	2	5	3	3	2.07E-01	4	0.7	1.03
*1886.1409	0	17	0	17	16	1	16	3.70E-04	10	2.6	1.05
1889.6308	0	14	1	13	13	2	12	(9.78E-04)			0.95
1889.75625	0	14	2	13	13	1	12	3.10E-03	4	5.1	0.95
1890.4791	0	12	3	9	11	4	8	7.38E-04	4	-1.6	0.84
1893.1798	-14	4	4	1	4	1	4	6.55E-04	15	6.8	1.14
1893.42146	0	12	3	10	11	2	9	8.29E-03	4	-1.0	0.91
1894.90460	3	5	3	3	4	0	4	2.63E-02	4	8.0	1.11
1897.85209	2	7	4	4	6	3	3	9.80E-02	3	-2.1	1.01
1902.60678	0	7	3	4	6	2	5	1.80E-01	5	-4.7	1.06
1907.06283	-2	13	2	11	12	3	10	2.73E-03	4	3.2	0.89
1907.38144	0	15	1	14	14	2	13	7.70E-04	5	-6.9	0.95
1907.4434	0	15	2	14	14	1	13	2.50E-04	10	-9.5	0.95
1907.68095	-1	5	5	1	4	4	0	2.40E-01	5	-3.7	1.02
1907.71252	1	5	5	0	4	4	1	7.30E-01	3	-2.3	1.03
1911.32218	0	13	3	11	12	2	10	9.25E-04	3	3.9	0.89
1911.4960	-5	9	4	5	9	1	8	1.03E-03	7	-4.1	1.24
1911.86897	-3	8	4	5	7	3	4	1.26E-01	4	-4.0	1.00
1913.7591	-11	5	4	2	5	1	5	(3.26E-04)			1.18
1913.93134	-2	7	4	3	6	3	4	2.77E-01	3	-0.7	1.03
1920.0916	-9	8	3	5	8	0	8	3.16E-04	10	6.7	1.27
1922.08990	3	13	3	10	12	4	9	7.66E-04	4	5.1	0.83
1922.39335	-2	9	4	6	8	3	5	1.85E-02	3	3.3	0.97
1923.6641	5	8	5	3	8	2	6	3.33E-04	10	-0.8	1.19
1926.5169	7	9	5	4	9	2	7	7.08E-04	10	5.9	1.21
1927.6094	3	7	5	2	7	2	5	8.70E-04	15	-14.1	1.17
*1927.9299	35	8	8	1	8	7	2	7.10E-04	5	-1.1	0.95
*1929.4237	11	9	8	1	9	7	2	4.70E-04	10	-1.4	0.95
1929.81820	0	14	3	12	13	2	11	8.10E-04	4	5.5	0.88
1930.70157	-7	10	4	7	9	3	6	2.07E-02	3	-0.5	0.94
1932.11675	2	6	5	2	5	4	1	3.92E-01	3	-1.4	1.03
1932.39062	-5	6	5	1	5	4	2	1.30E-01	3	-1.8	1.02
1935.6968	-23	6	5	1	6	2	4	(2.13E-04)			1.19
1937.17075	-3	6	3	4	5	0	5	5.27E-02	4	2.1	1.13
1938.38312	-6	11	4	8	10	3	7	2.55E-03	4	0.9	0.92
1938.69576	0	7	2	5	6	1	6	5.08E-02	3	4.1	1.12
1940.1675	16	6	4	3	6	1	6	6.90E-04	10	-12.1	1.24
1944.1257	12	4	4	1	3	1	2	3.30E-03	5	2.5	1.16
1946.19844	4	8	4	4	7	3	5	3.35E-02	3	-4.8	1.03
1947.09567	12	12	4	9	11	3	8	2.42E-03	3	-5.5	0.89
1947.3507	0	15	2	13	14	3	12	1.64E-04	15	-20.9	0.87
1954.40617	-4	8	3	5	7	2	6	1.91E-02	3	2.8	1.08
1955.73421	0	7	5	3	6	4	2	6.37E-02	3	1.0	1.03
1957.02920	-2	7	5	2	6	4	3	1.85E-01	3	-2.1	1.03
1958.1040	0	13	4	10	12	3	9	2.54E-04	10	-2.7	0.86
1964.17174	0	5	4	2	4	1	3	3.45E-03	3	3.3	1.16
1971.7894	0	14	4	11	13	3	10	2.15E-04	10	-0.1	0.84
1975.4622	55	4	4	0	3	1	3	3.62E-04	15	-8.8	1.23
1977.62982	-1	8	5	4	7	4	3	7.90E-02	3	-1.5	1.02
1980.76133	7	6	6	1	5	5	0	1.99E-01	3	-3.7	1.05
1980.7660	93	6	6	0	5	5	1	6.62E-02	3	-3.9	1.05
1981.99052	-1	8	5	3	7	4	4	2.52E-02	3	-5.1	1.02
1984.2888	-1	7	3	5	6	0	6	9.25E-03	4	2.7	1.17
1984.55328	1	9	4	5	8	3	6	3.52E-02	3	7.6	1.04
1987.15301	-4	6	4	3	5	1	4	1.68E-02	4	3.0	1.17
1996.53035	-1	9	5	5	8	4	4	1.03E-02	6	2.2	1.00
2002.64703	-3	8	2	6	7	1	7	5.55E-03	5	3.2	1.17
2005.60255	-3	7	6	2	6	5	1	3.10E-02	4	-4.5	1.05

Table 7. *Continued*

Observed Position	o − c	Upper J	Upper K_a	Upper K_c	Lower J	Lower K_a	Lower K_c	Observed Strength	%s	(o − c)%	R	Observed Position	o − c	Upper J	Upper K_a	Upper K_c	Lower J	Lower K_a	Lower K_c	Observed Strength	%s	(o − c)%	R
2005.64419	-8	7	6	1	6	5	2	9.30E-02	4	-4.5	1.05	2095.44171	0	11	6	6	10	5	5	5.10E-04	6	-2.7	1.00
2008.08019	-7	9	5	4	8	4	5	2.95E-02	3	0.5	1.02	2102.95935	0	9	7	3	8	6	2	2.30E-03	4	3.4	1.12
2011.31860	1	10	5	6	9	4	5	1.07E-02	4	4.6	0.98	2102.99792	0	9	7	2	8	6	3	6.61E-03	3	-0.9	1.12
2012.79147	-4	9	3	6	8	2	7	1.48E-02	4	0.4	1.11	2106.68387	0	7	5	3	6	2	4	4.44E-04	10	0.0	1.50
2015.28200	0	7	4	4	6	1	5	5.55E-03	4	2.7	1.18	2108.0117	0	12	5	7	11	4	8	1.83E-04	10	-0.8	1.02
2015.3286	10	5	4	1	4	1	4	2.01E-03	10	-0.3	1.30	2113.9680	24	7	4	3	6	1	6	8.23E-04	6	-8.2	1.56
2021.79805	7	11	5	7	10	4	6	1.05E-03	5	-0.4	0.94	2122.8768	0	8	5	4	7	2	5	1.36E-03	6	-7.8	1.44
2028.85062	0	12	5	8	11	4	7	9.05E-04	7	-0.8	0.91	*2123.62142	4	8	8	1	7	7	0	9.13E-03	5	-3.1	1.31
2029.99777	2	8	6	3	7	5	2	4.02E-02	3	-2.2	1.05	2127.18945	2	10	7	4	9	6	3	2.26E-03	5	1.7	1.10
2030.23180	3	8	6	2	7	5	3	1.33E-02	4	-3.0	1.05	2127.36459	-5	10	7	3	9	6	4	7.50E-04	5	1.3	1.10
2030.30047	0	10	4	6	9	3	7	2.75E-03	5	-0.4	1.05	2130.7986	-18	10	2	8	9	1	9	4.50E-04	5	-16.0	1.32
2035.14352	-2	8	3	6	7	0	7	1.18E-02	4	1.9	1.22	2135.73632	9	10	4	7	9	1	8	1.65E-03	10	-7.7	1.28
2036.61951	-11	10	5	5	9	4	6	3.12E-03	4	0.4	1.01	2141.4585	8	11	3	8	10	2	9	8.60E-04	10	0.7	1.23
2049.72415	-6	8	4	5	7	1	6	1.05E-02	4	-0.3	1.19	2142.7468	-34	9	5	5	8	2	6	4.00E-04	10	0.7	1.40
2053.5810	8	9	6	4	8	5	3	5.10E-03	4	-1.5	1.04	2143.84620	1	10	3	8	9	0	9	1.44E-03	10	1.2	1.35
2054.51442	3	9	6	3	8	5	4	1.55E-02	4	0.0	1.04	*2149.1255	-28	9	8	1	8	7	2	3.35E-03	5	-1.8	1.30
2061.1502	7	6	4	2	5	1	5	5.48E-04	10	-3.9	1.39	2150.5904	0	11	7	5	10	6	4	2.29E-04	10	3.6	1.08
2067.28145	-9	9	2	7	8	1	8	4.96E-03	3	-4.3	1.23	2151.21655	0	11	7	4	10	6	5	7.00E-04	10	5.6	1.08
2069.34572	-3	11	5	6	10	4	7	2.54E-03	4	1.8	1.01	2157.61134	-4	7	5	2	6	2	5	4.30E-04	15	-11.7	2.12
2075.72220	-1	10	6	5	9	5	4	5.26E-03	10	0.5	1.02	2168.3182	0	10	5	6	9	2	7	7.00E-04	10	1.4	1.39
2075.8999	-31	10	3	7	9	2	8	1.20E-03	6	-1.0	1.16	2174.2290	0	10	8	3	9	7	2	8.55E-04	8	3.0	1.28
2078.1677	70	8	7	2	7	6	1	1.83E-02	5	2.0	1.12	2174.2355	0	10	8	2	9	7	3	2.85E-04	8	3.0	1.28
2078.1733	17	8	7	1	7	6	2	6.10E-03	5	2.0	1.13	*2192.1074	0	9	9	0	8	8	1	1.08E-03	7	-11.6	1.67
2078.65779	-4	10	6	4	9	5	5	1.84E-03	6	5.8	1.03	2192.4270	-28	11	2	9	10	1	10	3.38E-04	15	-34.2	1.42
2083.4524	-4	11	4	7	10	3	8	1.75E-03	4	-2.0	1.08	2198.8045	0	11	8	4	10	7	3	{7.99E-05}			
2088.6488	7	9	3	7	8	0	8	1.57E-03	4	9.1	1.27	2198.8349	0	11	8	3	10	7	4	2.38E-04	10	-1.2	1.25
2090.22715	0	9	4	6	8	1	7	1.74E-03	5	6.3	1.23	*2219.16827	0	10	9	2	9	8	1	4.14E-04	10	8.5	1.67
2091.7513	21	6	5	2	5	2	3	8.50E-04	10	-3.6	1.56												

[a] An asterisk denotes a doubled absorption, with the quantum assignment given for the stronger transition. The strength given represents the sum of the strengths of the two comparable transitions. o − c is the observed minus the computed line position in inverse centimeters times 10^5. The computed values are derived from energy levels given in Table 2. %s is the estimated uncertainty in the measured line strength given in percent. Line strengths given within braces are the computed values derived in this study; (o − c)% is the observed minus the computed line strength in percent. *R* is the ratio of the computed line strength derived in this study to that given in Ref. 7.

resulted in the most accurate representation of the experimental values was to separate the line strengths into two regions for each isotopic species and to fit each set. The first set contained line strengths whose line frequencies were lower than 1700 cm^{-1}, and the second set involved measurements for frequencies equal to and above 1700 cm^{-1}. Values and associated estimated uncertainties of the matrix elements derived from these fits are given in Table 5. The measured line strengths were least-squares fitted by using the expressions given in Eqs. (1)–(3) and outlined in Ref. 1. It should be noted that the measured line strengths were normalized to 100% of the isotopic sample, and these normalized values were used in the analyses. The lower portion of Table 5 lists the number of lines fitted in each set and the values of the standard deviation in percent, $\sigma\%$, resulting from the least-squares fit of the strengths. $\sigma\%$ is defined by

$$\sigma\% = 100\left\{\sum[(S_{\mathrm{obs}} - S_{\mathrm{cal}})/S_{\mathrm{obs}}]^2/N\right\}^{1/2}, \qquad (4)$$

where N is the number of lines included in the fit. The initial analysis included all the useful measured strengths in one fit per species: for $H_2{}^{17}O$, 623 lines with $\sigma\% =$ 7.0% and, for $H_2{}^{18}O$, 696 lines with $\sigma\% = 6.1\%$.

RESULTS

Tables 6 and 7 list 695 lines of $H_2{}^{17}O$ and 755 lines of $H_2{}^{18}O$ used in the $H_2{}^{17}O$ and $H_2{}^{18}O$ analyses, respectively. Entries for the tables include the observed line position, the observed minus the computed line position (o − c), rotational quantum assignments, the observed strength, the estimated uncertainty in the measured strength (%s), the observed minus the computed line strength in percent [(o − c)%], and the ratio R of the computed line strength to that given in the tabulation by Flaud *et al.*[7] (and in the 1986 edition of the HITRAN database[6]). The values for the line strength are normalized to 100% of the isotopic species in units of inverse square centimeters per atmosphere (1 atm = 760 Torr), whereas the values in Ref. 7 were given in $cm^{-1}/(mol\ cm^{-2})$ and reduced by the normal isotopic abundance (3.7×10^{-4} for $H_2{}^{17}O$ and 2.04×10^{-3} for $H_2{}^{18}O$, as defined in an early U.S. Air Force Geophysics Laboratory report[15]). Therefore values from Ref. 7 were converted to inverse centimeters per atmosphere by applying the factor 2.48×10^{19} and dividing the result by the proper isotopic abundance in natural water to determine the values of R given in Tables 6 and 7.

The observed positions are given to three, four, or five decimal places in Tables 6 and 7, which indicates the accu-

Table 8. Comparison of Computed Line Strengths of $H_2{}^{16}O$, $H_2{}^{17}O$, and $H_2{}^{18}O$ Transitions in the (010)–(000) Bands with Strengths ≥1 cm^{-2}/atm at 296 K[a]

Upper			Lower			Line Position (cm^{-1})			Line Strength		
J	K_a	K_c	J	K_a	K_c	$H_2{}^{16}O$	$H_2{}^{17}O$	$H_2{}^{18}O$	$H_2{}^{16}O$	$H_2{}^{17}O$	$H_2{}^{18}O$
4	3	2	5	4	1	1394.47444	1392.06589	1389.91037	1.35	1.33	1.30
4	2	3	5	3	2	1399.20424	1396.39468	1393.88010	1.15	1.14	1.11
3	3	0	4	4	1	1419.50800	1417.11992	1414.98367	2.51	2.49	2.44
3	2	1	4	3	2	1436.81824	1434.27312	1431.99900	2.52	2.51	2.44
5	1	4	6	2	5	1447.95163	1445.24439	1442.82604	1.06	1.08	1.06
6	1	6	7	0	7	1456.50979	1453.38420	1450.59911	1.48	1.50	1.48
2	2	1	3	3	0	1456.88707	1454.25978	1451.91143	4.13	4.11	3.99
2	1	2	3	2	1	1464.90510	1461.91156	1459.23783	2.12	2.12	2.04
3	1	2	4	2	3	1472.05123	1469.26527	1466.77783	2.56	2.59	2.52
5	0	5	6	1	6	1473.51420	1470.42862	1467.67641	2.48	2.52	2.47
2	1	1	3	2	2	1487.34854	1484.51094	1481.97746	1.18	1.19	1.16
6	1	6	6	2	5	1489.84197	1486.71571	1483.92606	1.04	1.05	1.01
4	1	4	5	0	5	1496.24891	1492.96540	1490.04041	3.55	3.61	3.52
1	1	1	2	2	0	1498.80321	1495.88383	1493.27694	1.31	1.31	1.27
1	1	0	2	2	1	1505.60428	1502.72747	1500.15891	4.62	4.65	4.51
3	0	3	4	1	4	1507.05833	1503.95603	1501.18833	4.63	4.72	4.59
4	1	4	4	2	3	1521.23453	1518.18747	1515.46698	2.60	2.60	2.52
5	0	5	5	1	4	1521.30905	1517.79418	1514.66212	2.09	2.09	2.02
2	0	2	3	1	3	1522.68612	1519.55708	1516.76581	1.72	1.74	1.69
3	1	3	3	2	2	1533.18231	1530.18393	1527.50686	1.05	1.05	1.02
3	2	1	3	3	0	1533.91656	1531.31129	1528.98353	1.86	1.86	1.83
2	1	2	3	0	3	1540.29980	1536.80972	1533.70044	3.99	4.08	3.96
4	0	4	4	1	3	1541.95418	1538.48140	1535.38411	1.22	1.22	1.17
2	1	2	2	2	1	1542.15983	1539.20207	1536.56131	2.70	2.70	2.63
5	2	3	5	3	2	1545.15664	1542.53773	1540.19383	1.94	1.96	1.95
5	1	4	5	2	3	1554.35239	1551.06033	1548.11831	3.15	3.15	3.09
0	0	0	1	1	1	1557.60923	1554.39454	1551.52702	1.41	1.43	1.39
3	0	3	3	1	2	1558.53092	1555.15017	1552.13398	5.72	5.72	5.54
4	1	3	4	2	2	1559.69016	1556.57647	1553.79439	1.60	1.59	1.57
3	1	2	3	2	1	1560.25720	1557.26841	1554.59873	5.32	5.35	5.23
2	0	2	2	1	1	1569.78867	1566.48895	1563.54525	2.41	2.41	2.35
1	0	1	1	1	0	1576.18544	1572.92818	1570.02258	6.36	6.41	6.25
1	1	0	1	0	1	1616.71155	1613.09923	1609.87981	5.71	5.85	5.68
2	1	1	2	0	2	1623.55918	1619.98809	1616.80593	2.04	2.09	2.01
2	0	2	1	1	1	1627.82748	1624.52838	1621.58525	1.01	1.03	1.03
1	1	1	0	0	0	1634.96711	1631.31501	1628.06006	1.44	1.49	1.45
3	1	2	3	0	3	1635.65190	1632.16657	1629.06134	4.40	4.53	4.35
3	2	1	3	1	2	1645.96935	1641.96896	1638.40771	3.94	4.07	3.98
4	2	2	4	1	3	1647.40410	1643.52721	1640.07770	1.16	1.18	1.16
3	0	3	2	1	2	1652.40036	1649.03292	1646.02824	5.61	5.78	5.74
2	1	2	1	0	1	1653.26710	1649.57383	1646.28221	5.88	6.12	5.99
5	2	3	5	1	4	1654.51124	1650.83272	1647.56215	2.16	2.19	2.15
2	2	1	2	1	2	1662.80930	1658.80020	1655.22987	1.94	2.05	1.98
3	1	3	2	0	2	1669.39294	1665.66108	1662.33533	2.32	2.40	2.39
4	0	4	3	1	3	1675.17276	1671.70954	1668.61926	2.26	2.33	2.34
5	1	4	5	0	5	1675.51515	1672.19278	1669.23014	1.26	1.33	1.27
4	2	3	4	1	4	1683.17799	1679.26484	1675.78039	1.64	1.74	1.67
5	3	2	5	2	3	1683.98366	1679.38539	1675.29607	1.17	1.20	1.21
4	1	4	3	0	3	1684.83520	1681.08877	1677.75049	7.23	7.48	7.53
3	3	0	3	2	1	1695.45946	1690.89317	1686.82796	1.13	1.20	1.18
5	0	5	4	1	4	1695.92820	1692.36935	1689.19408	6.36	6.55	6.68
2	2	1	1	1	0	1699.93392	1695.84060	1692.19509	4.32	4.56	4.47
5	1	4	4	2	3	1700.50077	1697.41485	1694.65671	1.74	1.77	1.80
4	3	2	4	2	3	1704.45343	1700.02437	1696.08313	1.21	1.23	1.25
2	2	0	1	1	1	1706.34926	1702.29737	1698.68909	1.21	1.24	1.25
6	1	6	5	0	5	1717.40549	1713.66410	1710.33016	5.06	5.11	5.10
3	2	2	2	1	1	1718.61168	1714.47353	1710.78806	1.26	1.30	1.28
7	0	7	6	1	6	1733.39061	1729.69245	1726.39451	3.45	3.49	3.48
4	2	3	3	1	2	1734.65058	1730.45898	1726.72603	3.18	3.27	3.23
3	2	1	2	1	2	1739.83879	1735.85171	1732.30197	2.18	2.24	2.20
8	1	8	7	0	7	1751.42329	1747.65063	1744.28822	2.11	2.13	2.13
7	1	6	6	2	5	1756.81887	1753.38976	1750.32342	1.16	1.18	1.18
6	2	5	5	1	4	1761.82858	1757.59202	1753.82160	1.86	1.91	1.89
9	0	9	8	1	8	1768.12019	1764.33499	1760.96062	1.15	1.16	1.16
3	3	0	2	2	1	1772.71419	1768.18368	1764.15144	3.46	3.60	3.57
4	3	2	3	2	1	1792.65940	1788.02751	1783.90403	2.37	2.46	2.44
5	3	2	4	2	3	1830.13204	1825.73991	1821.83447	1.28	1.27	1.25
4	4	1	3	3	0	1844.18067	1839.16461	1834.70140	1.98	1.98	1.97
5	4	1	4	3	2	1869.34567	1864.32859	1859.86543	1.19	1.18	1.17

[a] Line positions are also computed. The computed transition frequencies are derived from energy-level values obtained in this study for $H_2{}^{17}O$ and $H_2{}^{18}O$ and derived from values given in Ref. 1 for $H_2{}^{16}O$. The computed line strengths for $H_2{}^{16}O$ are taken from Ref. 1.

Table 9. Comparison of Computed Line Strengths between $H_2{}^{16}O$, $H_2{}^{17}O$, and $H_2{}^{18}O$ Transitions in the (010)–(000) Bands with Strengths $\geq 10^{-4}$ and $< 10^{-3}$ cm^{-2}/atm at 296 K[a]

Upper			Lower			Line Position (cm^{-1})			Line Strength		
J	K_a	K_c	J	K_a	K_c	$H_2{}^{16}O$	$H_2{}^{17}O$	$H_2{}^{18}O$	$H_2{}^{16}O$	$H_2{}^{17}O$	$H_2{}^{18}O$
8	2	6	9	5	5	1120.83199	1120.73848	1120.61522	3.10	3.30	3.49
6	2	4	7	5	3	1151.54389	1151.80089	1152.00245	3.97	4.08	4.37
9	2	8	10	3	7	1152.44405	1148.59025	1145.16522	9.20	9.23	9.31
5	1	5	6	4	2	1165.04880	1163.84299	1162.74600	5.41	5.29	5.34
9	0	9	9	3	6	1229.36368	1225.55739	1222.16169	1.77	1.70	1.45
10	6	5	11	7	4	1242.79913	1240.81254	1239.02806	8.32	8.66	8.74
6	1	6	6	4	3	1286.02852	1284.61999	1283.34390	9.61	9.43	9.18
9	9	0	10	10	1	1292.37138	1290.74410	1289.27910	2.48	2.43	2.42
14	1	14	15	0	15	1297.18346	1294.49273	1292.09696	6.05	5.94	6.28
5	1	5	5	4	2	1312.71458	1311.49551	1310.38930	3.95	3.89	3.82
6	2	4	6	5	1	1322.55790	1322.74120	1322.87812	2.32	2.44	2.52
13	1	12	14	2	13	1326.13480	1323.33405	1320.83757	5.53	6.10	6.02
4	1	4	4	4	1	1333.48904	1332.41736	1331.44359	7.22	7.19	7.06
9	2	7	9	5	4	1341.10070	1340.37158	1339.66804	7.20	7.71	7.75
12	1	11	13	2	12	1343.67838	1340.84318	1338.31730	6.68	7.21	7.23
13	1	13	13	2	12	1348.75662	1345.85916	1343.28104	5.22	5.62	5.36
11	3	9	12	2	10	1363.06264	1359.88416	1357.06712	7.52	7.95	7.91
11	4	8	12	3	9	1381.53127	1377.09422	1373.18900	2.26	2.42	2.37
13	2	12	13	3	11	1406.15052	1402.94210	1400.08718	3.27	3.50	3.47
13	3	11	13	4	10	1453.52441	1450.25170	1447.21630	1.76	1.93	2.01
10	5	6	11	4	7	1484.25730	1477.93817	1472.32199	4.13	4.43	4.41
10	7	4	10	8	3	1516.42749	1514.43243	1512.64214	5.20	5.54	5.59
6	1	5	5	4	2	1536.14923	1534.78525	1533.54437	8.05	8.51	8.43
8	5	3	9	4	6	1579.24711	1574.03567	1569.40708	8.16	7.44	7.74
8	3	5	9	2	8	1590.40421	1587.58880	1585.09452	8.21	7.68	7.44
7	6	2	8	5	3	1649.51909	1643.69530	1638.51105	3.25	3.31	3.59
11	4	8	11	3	9	1792.33058	1788.16314	1784.46511	9.15	9.58	9.59
12	4	9	12	3	10	1808.37193	1804.36332	1800.80434	7.16	7.71	7.74
12	1	11	12	0	12	1828.20791	1824.36261	1820.93330	5.19	5.48	5.47
10	6	4	10	5	5	1840.29811	1834.04745	1828.47629	5.72	6.10	6.23
4	4	0	4	1	3	1854.12165	1847.82218	1842.22650	8.41	8.98	9.90
8	7	1	8	6	2	1894.65358	1888.42263	1882.87928	8.49	9.35	9.81
9	7	3	9	6	4	1895.37937	1889.10670	1883.52637	4.23	4.65	4.92
10	7	4	10	6	5	1895.73830	1889.41515	1883.79049	5.06	5.66	5.96
14	1	13	13	2	12	1897.37239	1893.27940	1889.63080	8.86	9.77	9.78
4	4	1	4	1	4	1904.76087	1898.62814	1893.17994	5.06	5.31	6.10
15	1	14	14	2	13	1915.19557	1911.06340	1907.38144	7.25	8.22	8.23
13	3	11	12	2	10	1919.51347	1915.17100	1911.32218	8.26	8.94	8.89
13	3	10	12	4	9	1927.85947	1924.82990	1922.08987	6.73	7.42	7.27
8	5	3	8	2	6	1937.22038	1930.02920	1923.66405	2.61	2.85	3.30
9	5	4	9	2	7	1939.12451	1932.42973	1926.51683	5.32	5.74	6.66
8	8	1	8	7	2	1940.26738	1933.73857	1927.92955	4.31	4.96	5.38
7	5	2	7	2	5	1941.75733	1934.25861	1927.60937	7.53	8.29	9.93
9	8	1	9	7	2	1941.82823	1935.26308	1929.42359	2.80	3.23	3.57
6	4	3	6	1	6	1951.12921	1945.32243	1940.16734	6.22	6.45	7.73
4	4	0	3	1	3	1987.34023	1981.05032	1975.46165	3.44	3.65	3.94
12	5	8	11	4	7	2041.51131	2034.81050	2028.85062	8.64	9.25	9.12
6	4	2	5	1	5	2072.53993	2066.50657	2061.15013	4.92	5.23	5.69
6	5	2	5	2	3	2106.34669	2098.61652	2091.75109	6.73	7.64	8.81
11	6	6	10	5	5	2107.54635	2101.14590	2095.44171	4.94	5.30	5.24
7	5	3	6	2	4	2121.26806	2113.54175	2106.68387	3.47	3.93	4.44
7	4	3	6	1	6	2124.88690	2119.10045	2113.96776	7.52	8.00	8.90
10	2	8	9	1	9	2138.18845	2134.29042	2130.79878	4.65	4.91	5.22
10	7	3	9	6	4	2139.47892	2133.06695	2127.36464	6.75	7.38	7.40
11	3	8	10	2	9	2147.40554	2144.26784	2141.45842	7.76	8.23	8.54
9	5	5	8	2	6	2156.56416	2149.23487	2142.74714	3.18	3.59	3.97
11	7	4	10	6	5	2163.43045	2156.96560	2151.21655	5.96	6.70	6.61
7	5	2	6	2	5	2171.25580	2164.02650	2157.61138	3.45	4.00	4.80
10	5	6	9	2	7	2181.34399	2174.43043	2168.31820	5.54	6.31	6.90
11	2	9	10	1	10	2200.30574	2196.14919	2192.42798	3.64	4.04	4.54
10	9	2	9	8	1	2231.13708	2224.15430	2219.16827	2.18	2.67	2.84

[a] Strengths are in inverse square centimeters per atmosphere times 10^4. Line positions are also computed. The computed transition frequencies derived from the energy level values obtained in this study for $H_2{}^{17}O$ and $H_2{}^{18}O$ and derived from values given in Ref. 1 for $H_2{}^{16}O$. The computed line strengths for $H_2{}^{16}O$ are taken from Ref. 1.

racy of these measurements. Obviously, the most accurate estimates are given with five significant figures past the decimal, and, as was reported in Ref. 1, the absolute uncertainty for these measurements is $\pm 6 \times 10^{-5}$ cm^{-1}. The computed line positions were derived from the rotational energies given in Table 2. An asterisk next to the line-position value denotes a doubled absorption for which the two transitions were not adequately resolved in the spectra. The quantum assignments given for one of these features is for the stronger transition, and the value of the observed strength represents the sum of the strengths of the two comparable transitions.

Because of the close proximity of a few lines to other features of comparable or greater strength, only the line positions of these lines were determined with the aid of the LINEFINDER program, and therefore the observed strengths were not obtained. These lines are noted in Tables 6 and 7, with the line strengths (computed) given within braces. The computed line strengths were derived from the dipole moment expansion coefficients given in Table 5 and Eqs. (1)–(3). Not all the line-strength measurements given in the tables were included in the least-squares analyses. Entries with $\%s = 15\%$ were not included because these transitions resulted in averaged values with uncertainties of as much as 60% to possibly less than 10%. This range of uncertainty for each of these transitions arises for one or more of the following reasons: (a) blending, (b) weakness of the transition intensity, and (c) poor agreement between the values derived from the various spectra.

Several entries for the ratio R in Table 6 and six entries for R in Table 7 are missing because of the absence of these transitions in Ref. 7. The computations involved in creating the tabulation of Ref. 7 included lower limits for the line strengths for each isotopic species; transitions missing from Ref. 7 but included here have strengths that are lower than those lower limits.

DISCUSSION

In Ref. 7 the line strengths of the three isotopic species for the (010)–(000) bands were computed by using the transition moment constants quoted by Camy-Peyret and Flaud[16] for $H_2{}^{16}O$. Therefore in Ref. 7 it was assumed that, for a given transition, the strength (normalized to 100% of the species) is the same for all three isotopes, except for slight differences that are due to the lower-state energies. This is a reasonable assumption with regard to a first approximation for computing the $H_2{}^{17}O$ and $H_2{}^{18}O$ line strengths. The contents of Table 8 compare the computed strengths between $H_2{}^{16}O$, $H_2{}^{17}O$, and $H_2{}^{18}O$ for transitions with values greater than 1 cm^{-2}/atm; the results were derived from this study for $H_2{}^{17}O$ and $H_2{}^{18}O$ and from Ref. 1 for $H_2{}^{16}O$. Inspection of the contents of Table 8 shows that, on the average, the above assumption holds true for the strongest intensities of the (010)–(000) bands. Two transitions indicate a 4% difference between the $H_2{}^{16}O$ and $H_2{}^{18}O$ values, whereas the majority of the entries agree, within 2%, with one other.

A similar comparison is shown in Table 9 for the weaker transitions measured in this study and in the $H_2{}^{16}O$ study.[1] Inspection of the computed strengths listed in Table 9 shows a somewhat different picture for this comparison; a few transitions in the lower-frequency region have some agreement with one another, whereas for the $\Delta K_a = 3$ transitions in the high-frequency range there is little agreement between the values. For example, the 7 5 2–6 2 5 transition (2171.2558 cm^{-1} for $H_2{}^{16}O$) has a computed $H_2{}^{16}O$ strength that is 39% lower than that for $H_2{}^{18}O$ and 16% lower than the value shown for $H_2{}^{17}O$.

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