

Measurements of HDO between 4719 and 5843  $\text{cm}^{-1}$

Robert A. Toth

California Institute of Technology

Jet Propulsion Laboratory

Pasadena California 91109

Tables 3

## ABSTRACT

Fourier transform spectrometer data of heavy water vapor were obtained at resolutions of 0.01 and 0.02  $\text{cm}^{-1}$ . The spectra were analyzed to obtain line center frequencies and line strengths of  $\text{HD}^{16}\text{O}$  from 4719 to 5843  $\text{cm}^{-1}$ . The analysis included 1.700 assigned lines of the (011)-(000), (200)-(000), (120)-(000), and (021)-(010) bands. This is the first report of assignments in the weak (120)-(000) band which borrows much of its strength from the (200)-(000) band. The measurements provided in this work are a marked improvement over the HDO listing presently available on the HITRAN database in the spectral region.

## 1. INTRODUCTION

Several years ago, Toth and Brault (1) measured the positions, strengths, and self-broadened linewidths of over 1400 lines of HDO in the 3250-4370  $\text{cm}^{-1}$  region. The present study involves line position and strength measurements of HDO in the next higher region: specifically between 4719 and 5843  $\text{cm}^{-1}$ . This region contains ground-state vibration-rotation transitions of the (011)-(000), (200)-(000), (120)-(000), and (040)-(000) bands of HDO. This region was first investigated by Benedict et al. (2) who obtained spectra of heavy water between 2000 and 8000  $\text{cm}^{-1}$  and observed and assigned absorption lines of the (011)-(000) and (200)-(000) bands in the 2  $\mu\text{m}$  region. They obtained their data with a 0.3  $\text{cm}^{-1}$  resolution grating instrument and believed the measured tracings to be accurate to 0.2  $\text{cm}^{-1}$ . Their results were extended with computed line strengths and these values have been included on the HITRAN (3) database which contains 792 transitions of the (011)-(000) and (200)-(000) bands covering the region between 4850 and 5508  $\text{cm}^{-1}$ .

The present study includes measurements of 1700 assigned lines of the (011)-(000), (200)-(000), (120)-(000), and (021)-(010) bands of  $\text{HD}^{16}\text{O}$  in which rotational levels of the (021) state given in a recent report by Toth (4) were used to predict line positions of the "hot" band; (021)-(010). This study is the first report of assignments and measurements in the weak (120)-(000) band.

## 2. EXPERIMENT

As in the other HDO experiments (1,4-6) in which this author

has been involved, the data were obtained with the Fourier - transform spectrometer (FTS) located in the McMath solar telescope facility located at the Kitt Peak National Observatory. Absorption path lengths of 0.25 m, 2.39 m, 25 m, and 73 m were used with the latter two paths obtained with a 6-m base length multiple pass absorption cell. The data used in this study were also measured in two previous studies (1,4) . The spectral coverage of those spectra overlapped the present spectral region and the description of the samples and partial pressures were given in the earlier reports (1,4). Briefly, the HDO gas samples were obtained from a mixture of H<sub>2</sub>O and D<sub>2</sub>O from which the HDO abundances were near 50% of the total samples. The HDO partial pressures of the various runs were determined from the spectra and a complete description of the methods are given in refs. (1,4) .

The limiting spectral resolutions were 0.01 cm<sup>-1</sup> , 0.02 cm<sup>-1</sup>], and 0.012 cm<sup>-1</sup> with the 0.25 m path, 2.39 m path, and long paths, respectively. The shortest path length data were the same as that used in the earlier report (1) and the rest of the data were used in the analysis of the 1.4 μm region (4). The interferometric measurements were transformed into digitized spectral data that were analyzed with computer software (at JPL) that has been described in many past studies (see refs. (1,4-6)) .

The measured frequencies were off-set and corrected to known transition frequencies of the ν<sub>3</sub> band of HDO (1) and the ν<sub>1</sub> and ν<sub>2</sub> bands of H<sub>2</sub><sup>16</sup>O (7) and HDO lines reported in my recent report (4) . The HDO partial pressures of the gas samples were known from the

other reports (1,4) .

### 3. QUANTUM ASSIGNMENTS AND ENERGY LEVELS

The HITRAN (3) listing of HDO in this spectral region was used as an aid for assigning many of the measured absorption of the (011)-(000) and (200)-(000) bands observed in the spectra. The line assignments derived beyond the contents of the HITRAN (3) listing was done in a manner used in my recent study of HDO in the 1.4 $\mu$ m region (4). Briefly, the technique is based upon an iterative process in which known upper state and lower state rotational level values are inputted to a computer program as well as guesses for unknown upper state values. The program computes upper state levels and when matches were made for unassigned levels, these were inputted again as known values. The process was repeated several times. A few of the results from this method are shown in Table 1 for the (120)-(000) band. The table lists the experimental upper state rotational level value derived from the measured line position, rotational quantum assignments, the measured transition line frequency, the ground state rotational energy value (5) , and observed strength value. The observed line positions are given to 3,4 or 5 places beyond the decimal and signifies the estimated accuracy of the value with 5 places having the highest accuracy. D<sub>2</sub>O were known from one spectrum obtained with the gas sample having about 96% D<sub>2</sub>O and 4% HDO.

The upper state rotational levels were obtained by adding to each measured line frequency that was assigned, the ground state level given by Toth (5). These results were weighted and then

averaged for each level. Table 2 lists values of the term values obtained in this fashion for the (011), (200) # and (120) vibrational states along with associated estimated uncertainties.

#### 4. RESULTS

The majority of the HDO lines observed in the spectra were assigned and those not known were observed to be of medium to weak intensity in the spectrum obtained with the 73 m absorption path. A few of the unassigned lines may be of the very weak band, (040)-(000). Table 3 is a listing of the assigned lines observed in this work. The table gives the observed frequency, observed minus computed frequency, o-c times  $10^5$ , rotational quantum assignment, line strength (normalized to 100% of HDO) in  $\text{cm}^2/\text{atm.}$  at 296K, estimated uncertainty in the measured line strength, %s, ratio, R, of the line strength obtained in this work to that given in HITRAN (3) and the upper state vibrational numbers. Also included in the table are "hot" band lines of the (021) - (010) band and these are labeled "021H" for the vibrational notation. An asterisk preceding a line position value denotes a doubled absorption of which the two comparable transitions were not adequately resolved in the spectra to determine their respective parameters. The quantum assignment given for a doubled line represents one of the transitions and the value of the observed strength is the sum of the strengths of the two each with equal strength.

The computed frequencies of the ground state transitions were derived from the upper state energy levels given in Table 2 and the ground state levels given by Toth (5). The calculated positions

for the (021)-(010) band transitions were computed from the levels of the (021) state (4) and the (010) levels from Toth (5) . The measured line positions given with the highest accuracy (5 "places past the decimal) are known to  $6 \times 10^{-5} \text{ cm}^{-1}$  in precision whereas the absolute uncertainty is estimated to be  $\pm 10^{-4} \text{ cm}^{-1}$ .

The estimated uncertainties of the measured line strengths, %s, given in Table 3 vary from 2% to 15%. Those with %s=15% have a large range of uncertainties attached to the line strength values: from possibly less than 10% to over 50%. This rather large range was due to one or more of the following reasons: (a) blending, (b) weakness of transition, and (c) poor agreement between strength values derived from the various spectra for a given transition. The line strengths given in the HITRAN (3) listing are in units of  $\text{cm}^{-1}\text{cm}^2/\text{mol}$  at 296K and represent the normal HDO abundance in water vapor (3 parts in 104). They were converted to units and abundances used in this study by multiplying those values (3) by  $8.27 \times 10^{22}$  from which the values of the ratio, R, given in Table 3, were derived. Inspection of the table shows that, on the average, the HITRAN (3) line strength values are less than those in this study by a factor of 2 to 4. Values of R missing in the table denote that those vibration-rotation transitions were not included in the compilation (3) and not known prior to this study. Not given in Table 3 is a comparison between the line positions given here and on the HITRAN listing (3). This comparison shows that the HITRAN positions are accurate to about  $8 \times 10^{-3} \text{ cm}^{-1}$  , on the average, and this does not include transitions involving the 8 3 5

rotational level of the (200) state of which the transition frequencies are low by about  $36 \text{ cm}^{-1}$ .

## 5. DISCUSSION AND CONCLUSION

The majority of the transitions of the (120)-(000) band observed in this work are perturbed due to interactions between the (120) and (200) vibrational states. This study does not include perturbation calculations for these transitions which would involve both Fermi and Coriolis interactions. Even without those computations, the linelist given in Table 3 is a marked improvement over the HDO listing given in this spectral region that presently exists on the HITRAN (3) compilation.

The line positions and strengths of 1700 assigned transitions of HDO were measured between  $4719$  and  $5843 \text{ cm}^{-1}$ . Both A- and B-type transitions of the (011)-(000), (200)-(000), and (120)-(000) bands were included in the analysis however the majority of the measurements of the "hot" band, (021)-(010), were A-type transitions. Transitions of the (120)-(000) band have not been assigned in any prior study and the band strength is much weaker than those of either of the other two ground state bands analyzed in this study.

## 6. ACKNOWLEDGEMENTS

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Table 1. Examples of the experimental determinations of the rotational energy levels ( $\text{cm}^{-1}$ ) of the (120) vibrational state of  $\text{HD}^{16}\text{O}$  derived from the measured line frequencies ( $\text{cm}^{-1}$ ) of the (120)-(000) band and lower state' rotational levels ( $\text{cm}^{-1}$ ) .

upper state level	upper J K <sub>-</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed frequency	lower state level	strength <sup>2</sup>
5640.07227	2 2 0	3 2 1	5483.00756	157.06471	4.00E-04
5640.07221	2 2 0	2 2 1	5531.14597	108.92624	9.90E-04
5640.07301	2 2 0	2 1 1	5573.8885	66.18451	2.41E-05
5687.84207	3 2 1	4 3 2	5392.3548	295.48727	2.65E-05
5687.84162	3 2 1	4 2 2	5466.00550	221.83612	5.10E-04
5687.84146	3 2 1	3 2 2	5532.45246	155.38900	5.32E-04
5687.84143	3 2 1	3 1 2	5571.3801	116.46133	3.96E-05
5687.84150	3 2 1	2 2 0	5578.57242	109.26908	4.73E-04
5824.73846	5 2 4	6 2 5	5439.86290	384.87556	3.90E-04
5824.73803	5 2 4	5 2 3	5520.7432	303.99483	1.45E-04
5824.73765	5 2 4	5 1 5	5598.8728	225.86485	3.30E-05
5824.73778	5 2 4	4 2 3	5607.69588	217.04190	6.84E-04
5991.13106	7 1 6	8 2 7	5381.1845	609.94656	5.00E-05
5991.13121	7 1 6	8 1 7	5392.5681	598.56311	1.81E-04
5991.13136	7 1 6	6 2 5	5606.2558	384.87556	2.98E-05
5991.13078	7 1 6	6 1 5	5628.62363	362.50715	5.38E-04
6142.12689	8 2 7	9 2 8	5399.0295	743.09739	1.13E-04
6142.12609	8 2 7	8 1 8	5628.9189	513.20719	2.78E-05
6142.12683	8 2 7	7 2 6	5651.69945	490.42738	3.00E-04
6142.12567	8 2 7	7 1 6	5668.2080	473.91767	2.19E-05
6135.21214	9 1 9	10 0 10	5366.2821	768.93004	1.09E-04
6135.21156	9 1 9	8 1 8	5622.00437	513.20719	2.49E-04
6135.21172	9 1 9	8 0 8	5622.6959	512.51582	1.11E-04
6410.64379	11 1 11	10 1 10	5641.5269	769.1.1689	6.20E-05
6410.64384	11 1 11	10 0 10	5641.7138	768.93004	6.70E-05

1. taken from ref. 5

2. strengths given in  $\text{cm}^2/\text{atm.}$  at 296K.

Table 2. Rotational energy levels (cm<sup>-1</sup>) of the (011) , (200) and (120) vibrational states of HD<sup>16</sup>O. Estimated uncertainties given in cm<sup>-1</sup> x 10<sup>5</sup>

J	K <sub>a</sub>	K <sub>c</sub>	(011)	(200)	(120)	J	K <sub>a</sub>	K <sub>c</sub>
0	0	0	5089.53981	12	5363.82446	10	0	0
1	0	1	5105.01473	11	5378.76845	20	1	0
1	1	1	5120.07055	20	5392.95998	4	1	1
1	1	0	5123.04615	15	5395.50720	15	1	1
2	0	2	5135.55790	11	5400.33702	10	2	0
2	1	2	5148.03554	11	5420.28698	15	2	1
2	1	1	5156.95505	7	5427.92206	9	2	1
2	2	1	5201.86449	7	5470.20487	10	2	2
2	2	0	5202.26098	7	5470.51765	20	2	2
3	0	3	5180.40426	9	5451.92095	19	3	0
3	1	3	5189.73756	6	5461.08300	20	3	1
3	1	2	5207.52135	11	5476.31325	10	3	1
3	2	2	5248.23061	11	5514.96072	8	3	2
3	2	1	5250.16463	10	5516.49143	5	3	2
3	3	1	5329.91461	7	5591.32860	15	3	3
3	3	0	5329.94795	10	5591.35260	10	3	3
4	0	4	5238.62400	5	5508.75722	9	4	0
4	1	4	5244.92930	3	5515.14740	10	4	1
4	1	3	5274.34504	8	5540.36708	15	4	1
4	2	3	5309.71008	4	5574.36546	7	4	2
4	2	2	5315.21983	6	5578.75147	10	4	2
4	3	2	5392.34373	6	5651.44760	45	4	3
4	3	1	5392.57379	3	5651.61360	10	4	3
4	4	1	5504.15050	9	5756.56580	40	4	4
4	4	0	5504.15254	8	5756.56750	40	4	4
5	0	5	5309.45100	2	5578.17008	8	5	0
5	1	5	5313.34595	6	5582.26116	30	5	1
5	1	4	5356.82561	8	5619.61883	6	5	1
5	2	4	5386.01914	14	5648.19355	15	5	2
5	2	3	5397.85418	10	5657.70142	5	5	2
5	3	3	5470.48871	6	5726.69350	30	5	3
5	3	2	5471.38566	12	5727.34427	15	5	3
5	4	2	5582.03097	9	5831.52278	15	5	4
5	4	1	5582.05115	12	5831.53590	20	5	4
5	5	1	5723.27120	30	5965.14130	50	5	5
5	5	0	5723.27120	40	5965.14130	50	5	5
6	0	6	5392.49804	6	5659.76960	30	6	0
6	1	6	5394.74304	9	5662.21398	8	6	1
6	1	5	5454.13680	14	5713.42379	15	6	1
6	2	5	5476.81958	13	5736.17390	20	6	2
6	2	4	5498.02025	6	5753.38952	6	6	2
6	3	4	5564.28965	5	5817.03929	20	6	3
6	3	3	5566.86781	6	5818.91984	17	6	3
6	4	3	5675.66256	6	5921.61168	15	6	4
6	4	2	5675.76372	20	5921.67818	15	6	4
6	5	2	5816.42410	40	6054.76100	40	6	5
6	5	1	5816.43110	30	6054.76140	40	6	5
6	6	1	5985.68480	30	6216.03500	200	6	6
6	6	0	5985.68480	30	6216.03500	200	6	6
7	0	7	5487.68596	10	5753.43744	11	7	0
7	1	7	5488.91750	8	5754.82520	50	7	1
7	1	6	5565.27771	11	5820.97795	15	7	1
7	2	6	5581.73857	8	5838.00125	30	7	2
7	2	5	5615.24749	12	5865.50252	7	7	2
7	3	5	5673.59020	15	5922.34981	15	7	3
7	3	4	5679.61422	20	5926.82814	0	7	3
7	4	4	5785.09972	8	6026.08220	15	7	4
7	4	3	5785.46011	12	6027.12169	15	7	4
7	5	3	5925.25093	15	6159.41875	50	7	5
7	5	2	5925.24970	30	6159.42350	45	7	5
7	6	2	6093.98170	80	6320.15660	35	7	6
7	6	1	6093.98170	80	6320.15660	35	7	6
7	7	1	6289.71949	7	6508.13820	25	7	7
7	7	0	6289.71949	7	6508.13820	25	7	7

Table 2. continued

J	K <sub>a</sub>	K <sub>c</sub>	(011)	(200)	(120)	J	K <sub>a</sub>	K <sub>c</sub>				
8	0	8	5595.06338	15	5859.19133	20	6014.25690	10	8	0	8	
8	1	8	5595.71589	15	5859.95069	7	6016.04935	25	8	1	8	
8	1	7	5689.25710	9	5941.43039	10	6117.85498	15	8	1	7	
8	2	7	5700.39281	6	5953.35692	15	6142.12685	15	8	2	7	
8	2	6	5748.79386	4	5993.48035	15	6186.82280	20	8	2	6	
8	3	6	5798.13446	12	6042.46677	20	6275.76120	45	8	3	6	
8	3	5	5810.14138	5	6051.54499	18	6283.07160	40	8	3	5	
8	4	5	5910.35862	13	6147.35998	40	6447.02198	50	8	4	5	
8	4	4	5911.39832	17	6148.05718	10	6447.41110	35	8	4	4	
8	5	4	6049.77007	12	6279.16670	40			8	5	4	
8	5	3	6049.79592	14	6279.17870	15			8	5	3	
8	6	3	6217.82420	30	6439.21320	80			8	6	3	
8	6	2	6217.82516	40	6439.21320	80			8	6	2	
8	7	2	6412.98210	30	6626.56080	20			8	7	2	
8	7	1	6412.98210	30	6626.56080	20			8	7	1	
8	8	1	6633.72494	20	6840.27455	25			8	8	1	
8	8	0	6633.72494	20	6840.27455	25			8	8	0	
9	0	9	5714.68969	15	5977.07707	8	6134.13142	40	9	0	9	
9	1	9	5715.02758	13	5977.48209	20	6135.21165	15	9	1	9	
9	1	8	5825.35239	6	6074.08080	30	6257.56082	60	9	1	8	
9	2	8	5832.41680	30	6081.92426	20	6275.94280	30	9	2	8	
9	2	7	5897.73225	7	6136.60095	22			9	2	7	
9	3	7	5937.58197	9	6177.11631	25	6417.16246	20	9	3	7	
9	3	6	5958.62471	8	6193.29265	10	6430.61490	50	9	3	6	
9	4	6	6051.39149	12	62 83.01300	300	6589.45737	50	9	4	6	
9	4	5	6053.97915	20	6284.76826	8	6590.43095	50	9	4	5	
9	5	5	6190.03992	20	6414.01003	7			9	5	5	
9	5	4	6190.16112	30	6414.09160	15			9	5	4	
9	6	4	6357.23324	25	6573.22110	80			9	6	4	
9	6	3	6357.24040	40	6573.22130	80			9	6	3	
9	7	3	6551.67690	40	6759.81065	50			9	7	3	
9	7	2	6551.67760	40	6759.81065	50			9	7	2	
9	8	2	6771.75180	30	6972.78830	60			9	8	2	
9	8	1	6771.75180	30	6972.78830	60			9	8	1	
9	9	1	7016.07300	20	7211.25935	50			9	9	1	
9	9	0	7016.07300	20	7211.25935	50			9	9	0	
10	0	10	5846.60245	20	6107.12650	20	6266.12030	30	10	0	10	
10	1	10	5846.77455	8	6107.33884	6	6266.76815	10	10	1	10	
1	0	1	5973.23551	15	6218.53080	45	6409.75215	30	1	0	1	9
1	0	2	5977.48801	17	6223.41550	10	6423.26767	15	1	0	2	9
1	0	2	6060.99224	10	6294.00700	40	6504.80777	20	1	0	2	8
1	0	3	6091.53120	15	6325.97900	14	6573.66293	40	1	0	3	8
1	0	3	6124.75816	35	6351.95512	25	6596.13365	50	1	0	3	7
1	0	4	6208.06448	15	6433.79990	30			1	0	4	7
1	0	4	6213.61283	8	6437.46700	300			1	0	4	6
1	0	5	6346.08910	21	6564.01660	8			1	0	5	6
1	0	5	6346.45905	15	6564.25440	50			1	0	5	5
1	0	6	6512.23963	40	6722.20277	15			1	0	6	5
1	0	6	6512.25400	100	6722.21020	15			1	0	6	4
1	0	7	6705.80705	35	6907.88720	20			1	0	7	4
1	0	7	6705.80705	35	6907.88744	30			1	0	7	3
1	0	8	6925.09324	58					1	0	8	3
1	0	8	6925.09324	58					1	0	8	2
1	0	9	7168.62400	30					1	0	9	2
1	0	9	7168.62400	30					1	0	9	1
11	0	11	5990.81187	15	6249.34821	8	6410.25970	30	11	0	11	
11	1	11	5990.89856	6	6249.45440	20	6410.64375	20	11	1	11	
11	1	10	6132.88035	5	6374.66021	15	6574.15890	30	11	1	10	
11	2	10	6135.33997	10	6377.54542	7	6583.84348	50	11	2	10	
1	1	2	6237.44476	20	6464.75870	30			1	1	2	9
1	1	3	6259.55643	7	6488.69055	10			1	1	3	9
1	1	3	6307.82925	12	6527.12072	15			1	1	3	8
1	1	4	6380.19035	25	6599.52375	20			1	1	4	8
1	1	4	6390.88063	10	6607.01740	30			1	1	4	7
1	1	5	6517.91489	15	6729.18610	30			1	1	5	7
1	1	5	6518.88110	25	6729.79485	15			1	1	5	6

Table 2. continued

J	K <sub>a</sub>	K <sub>c</sub>	(011)	(200)	(120)	J	K <sub>a</sub>	K <sub>c</sub>
1	1	6	6	6682.85845	20	68	86.18355	20
1	1	6	5	6682.89074	20	6886.20920	20	
1	1	7	5	6875.36500	200			
1	1	7	4	6875.36770	200			
1	1	8	4	7093.73333	10			
1	1	8	3	7093.73333	10			
12	0	12		6147.31040	30	6403.72989	15	
12	1	12		6147.35420	10	6403.78628	20	
12	1	11		6304.38558	12	6542.52563	20	
12	2	11		6305.76700	15	6544.19845	30	
12	2	10		6426.10230	30	6647.94138	8	
12	3	10		6441.20850	30	6664.90330	20	
1	2	3	9	6506.86785	20	6718.03560	20	
1	2	4	9	6567.35110	25	6779.96584	15	
1	2	4	8	6586.12770	40	6793.42890	70	
1	2	5	8	6705.46430	80	6909.49840	30	
1	2	5	7	6707.67370	90	6910.91637	20	
1	2	6	7	6869.09850	40	7065.20245	90	
1	2	6	6	6869.22545	50	7065.27860	30	
12	7	6		7060.32770	20			
1	2	7	5	7060.32848	50			
1	2	8	5	7277.65076	190			
1	2	8	4	7277.65076	190			
13	0	13		6316.07690	50	6570.28624	40	
13	1	13		6316.09811	8	6570.28527	40	
13	1	12		6487.85680	40	6722.27046	10	
13	2	12		6488.61770	20	6723.15353	8	
13	2	11		6626.28250	40	6842.83871	20	
13	3	11		6636.03200	300	6854.23396	20	
13	3	10		6720.67365	30	6923.81910	20	
13	4	10		6769.23535	30			
1	3	4	9	6799.25915	25			
1	3	5	9	6905.50770	50			
1	3	5	8	6908.51514	30			
1	3	6	8	7070.94610	35			
13	6	7		7071.28441	50			
14	0	14		6497.08484	40	6748.90000	100	
14	1	14		6497.09577	40	674 B.90000	100	
14	1	13		6683.36930	20	6913.74144	300	
14	2	13		6683.78055	25	6914.26450	90	
14	2	12		6837.88290	30			
14	3	12		6844.51238	400			
14	3	11		6940.90600	160			
14	4	11		6985.10539	80			
14	4	10		7029.77840	80			
15	0	15		6690.29700	300	6939.60247	30	
15	1	15		6690.30200	300	6939.60247	30	
15	1	14		6890.95400	100			
15	2	14		6891.17240	100			
16	0	16		6895.60659	50	7142.35340	30	
16	1	16		6895.68659	50	7142.35340	30	
17	0	17		7113.19128	25	7357.08435	30	
17	1	17		7113.19128	25	7357.08435	30	
18	0	18		7342.80359	60			
18	1	18		7342.80359	60			

Table 3. Measured line positions (cm<sup>-1</sup>) and strengths' of the (011)-(000), (200)-(000), (1.20)-(000), and (021)-(010) bands of HD<sup>16</sup>O

observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength %s	R	band	observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength %s	R	band
4719.0878	-20	9 1 8 1 0 4 7		1.98E-05 15		011	4841.00049	23	8 2 7 9 3 6		3.93E-04 3		011
4719.2346	46	9 1 9 1 0 3 8		2.06E-05 15		011	4841.93649	6	5 0 5 6 3 4		1.58E-04 6		011
4727.2549	15	8 3 5 9 5 4		1.956-05 15		011	4841.9996	11	11 3 8 12 4 9		6.33E-05 3		011
4731.0578	4	7 3 5 8 5 4		2.1433-05 15		011	4842.53779	25	7 4 4 8 5 3		7.93E-04 3		011
4737.0521	6	7 3 4 8 5 3		2.47E-05 15		011	4842.92771	4	7 4 3 8 5 4		7.86E-04 3		011
4739.6788	-85	8 1 7 9 4 6		2.64E-05 15		011	4845.8310	-38	5 1 5 6 3 4		1.54E-04 2		011
●4744.21750	21	8 8 ) 9 9 0		2.85E-05 6		011	4846.32018	44	10 3 7 11 4 8		1.54E-04 3		011
4748.85411	-5	6 3 3 7 5 2		2.718-05 10		011	4846.49843	-38	8 3 6 9 4 5		5.91E-04 3		011
●4749.3422	-40	9 7 2 1 0 8 3		3.77E-05 10		011	4847.8339	25	3 2 1 4 4 0		5.01E-05 4		011
4749.8396	54	9 0 9 1 0 2 8		2.96E-05 15		011	●4850.48085	17	5 5 1 6 6 0		2.33E-03 5	2.91	011
4750.1766	-35	9 1 9 1 0 2 8		3.72E-05 15		011	●4850.5456	255	1 5 0 1 5 1 6 0 1 6		3.06E-04 3		011
4750.81556	20	8 2 7 9 4 6		4.19E-05 10		011	4852.36041	9	9 3 6 1 0 4 7		3.17E-04 4		011
4753.69604	29	8 0 8 9 3 7		4.57E-05 10		011	4853.4818	-49	7 1 6 8 3 5		2.58E-04 2		011
4754.34815	-11	8 1 8 9 3 7		3.75E-05 10		011	4853.8960	-162	1 5 1 1 4 1 6 1 1 5		3.37E-05 5		011
4756.7140	-54	7 1 6 8 4 5		3.24E-05 10		011	4853.9845	29	15 2 14 16 2 15		3.30E-05 5		011
4761.3222	11	5 3 3 6 5 2		2.86E-05 15		011	4854.1155	-52	15 2 14 16 1 15		1.99E-05 10		011
4761.5303	32	11 5 7 12 6 6		2.00E-05 15		011	4857/.64906	15	6 4 3 7 5 2		1.40E-03 4	3.52	011
4762.21777	-8	5 3 2 6 5 1		3.05E-05 10		011	4857.7010	-19	6 3 3 6 5 2		1.70E-05 15		011
4762.5951	-17	11 5 6 12 6 7		2.26E-05 5		011	4857.75700	-5	6 4 2 7 5 3		1.33E-03 3	3.31	011
●4764.0336	-112	8 7 2 9 8 1		8.00E-05 15		011	4860.56387	-6	8 0 3 5 9 4 6		6.36E-04 2		011
4766.4816	86	10 1 9 1 1 3 8		2.487E-05 15		011	4861.6070	-55	7 3 4 7 5 3		2.37E-05 15		011
*4769.4965	373	9 6 4 1 0 7 3		9.00E-05 15		011	4864.19675	-20	7 3 5 8 4 4		1.16E-03 3	4.09	011
4770.7335	26	10 2 9 1 1 3 8		5.00E-05 15		011	4864.9580	-10	4 0 4 5 3 3		1.19E-04 5		011
4770.8133	48	6 1 5 7 4 4		2.65E-05 15		011	4867.2225	54	1 4 2 1 2 1 5 2 1 3		5.02E-05 15		011
4773.1752	-20	7 2 6 8 4 5		6.05E-05 5		011	4869.05001	10	14 1 13 15 1 14		1.12E-04 3		011
4773.7532	-12	10 2 8 11 4 7		2.11E-05 15		011	4869.2149	39	1 4 2 1 3 1 5 2 1 4		1.14E-04 3		011
4775.9935	58	10 5 6 1 1 6 5		5.40E-05 10		011	4869.94326	11	7 2 6 8 3 5		9.45E-04 2		011
4776.3754	43	4 3 2 5 5 1		2.28E-05 15		011	4871.05092	13	7 3 4 8 4 5		1.18E-03 2	3.72	011
4776.3972	3	10 5 5 11 6 6		5.13E-05 5		011	4871.26338	-2	4 1 4 5 3 3		1.70E-04 2		011
4778.11253	-3	11 3 9 12 4 8		3.72E-05 5		011	4872.17463	-9	6 1 5 7 3 4		3.50E-04 3		011
●4778.84115	-4	7 7 0 8 8 1		1.54E-04 5		011	4872.37457	5	6 0 6 7 2 5		2.9011-04 2		011
4780.3903	18	11 4 8 1 2 5 7		3.98E-05 10		011	4872.86320	4	5 4 2 6 5 1		2.1 OE-03 5	3.10	011
●4784.25275	125	8 6 3 9 7 2		2.03E-04 10		011	4872.88441	-12	5 4 1 6 5 2		2.17E-03 6	3.20	011
4786.06536	-16	7 0 7 8 3 6		8.20E-05 15		011	4873.71675	1	9 1 0 9 4 5		1.33E-05 15		011
4786.97233	-9	9 2 7 1 0 4 6		4.20E-05 10		011	4873.74513	49	13 2 11 14 3 12		3.26E-05 15		011
4787.29719	13	7 1 7 8 3 6		6.50E-05 10		011	4874.2719	61	13 1 10 14 3 11		9.75E-05 4		011
4790.57938	20	9 5 5 1 0 6 4		1.15E-04 6		011	4874.61957	5	6 7 6 7 2 5		5.706-04 3		011
4790.71080	9	9 5 4 1 0 6 5		1.11E-04 7		011	4876.3707	6	13 4 9 14 4 10		5.80E-05 10		011
4793.4190	-31	8 0 8 9 2 7		5.50E-05 10		011	4879.8646	75	8 1 7 8 4 4		3.08E-05 15		011
4793.49585	25	6 2 5 7 4 4		8.00E-05 10		011	4880.1661	9	6 1 5 6 4 3		6.366-05 15		011
4794.07168	-14	8 1 8 9 2 7		9.20E-05 10		011	4880.38553	24	13 2 11 14 2 1a		1 388-04 10		011
4796.7444	-2	10 4 7 11 5 6		9.20E-05 6		011	4880.67952	3	6 1 4 7 4 3		2 03E-03 4	1 71	011
4797.15782	-39	8 2 6 9 4 5		6.77E-05 10		011	4882.8580	-22	12 2 14 11 11		8 05E-05 5		011
●4799.14525	-4	7 6 2 8 7 1		3.84E-04 4		011	4883.331	74	13 6 11 14 6 14		●00E 04 10		011
4800.7836	-20	9 1 8 1 0 3 7		6.58E-05 10		011	4883.340	29	13 1 11 14 1 14		1 00E 03 10		011
4803.04608	5	10 4 6 1 1 5 7		9.26E-05 2		011	4883.54337	-46	6 1 1 7 4 4		2 10E 03 4	3 79	011
4804.2923	3	10 3 8 1 1 4 7		1.05E-04 6		011	4883.9204	-7	8 1 0 8 1 5		1 50E 05 15		011
4805.33035	15	8 5 4 9 6 3		2.29E-04 5		011	4883.9515	36	13 1 12 14 1 11		2 67E 04 2		011
4805.35879	12	8 5 3 9 6 4		2.32E-04 4		011	4884.25415	15	13 2 12 14 1 11		2 65E 04 2		011
4805.85409	-15	7 2 5 8 4 4		8.23 E-05 3		011	4884.3922	-9	13 4 10 14 4 11		6 48 0\ 4		011
4807.84861	40	9 2 8 1 0 3 7		1.41E-04 3		011	4884.7119	-14	13 2 12 14 1 11		1 10E 04 5		011
4812.1278	-58	5 2 4 6 4 3		9.05E-05 2		011	4884.9173	31	3 0 1 4 1 2		6 05E 05 15		011
4812.30241	17	9 4 6 1 0 5 5		2.03E-04 2		011	4885.6847	0	13 5 14 5 10		1 25E 05 15		011
●4814.15295	-22	6 6 0 7 7 1		6.60E-04 2		011	4887.16200	2	5 1 4 6 1 1		3 04E 04 1		011
4814.4102	5	6 2 4 7 4 3		8.96E-05 15		011	●4888.18243	72	4 4 1 5 5 0		6 59E 01 1		011
4815.18463	-6	9 4 5 1 0 5 6		2.07E-04 3		011	4890.9995	-6	8 2 7 8 4 4		5 10E 05 16		011
4815.59333	2	6 0 6 7 3 5		1.17E-04 3		011	4892.6836	-75	12 4 8 13 4 9		1 72E 04 4		011
4816.8074	12	17 0 17 18 0 18		4.19E-05 10		011	4893.37010	-4	12 2 10 13 2 11		3.60E 04 10		011
4817.83833	2	6 1 6 7 3 5		1.08E-04 3		011	4894.25039	10	3 1 3 4 3 2		1.51E M 4		011
4820.24668	-34	7 5 3 8 6 2		8.28E-04 4		011	4894.85747	-3	6 2 5 7 3 4		1.98E-03 5	4 , *	011
4823.88368	11	5 2 3 6 4 2		9.58E-05 4		011	4896.4824	8	10 2 8 11 3 9		3.05E-04 2		011
4826.82207	-7	9 3 7 1 0 4 6		2.68E-04 2		011	4896.51805	-5	5 3 3 6 4 2		3.22E-03 2	1 10 0	011
4827.47204	5	8 4 5 9 5 4		4.17E-04 2		011	4897.49488	-2	5 3 2 6 4 3		3.26E-03 2	1 11 0	011
4828.61315	-7	8 4 4 9 5 5		4.20E-04 2		011	4897.7285	-24	12 1 1 1 3 2 1 2		2.38E-04 2		011
4829.4671	-31	4 2 3 5 4 2		8.21E-05 15		011	4897.96421	-21	1 2 3 1 0 1 3 3 1 1		3.28E-04 5		011
4829.8646	5	8 1 7 9 3 6		1.36E-04 5		011	4898.12840	-7	7 2 6 7 4 3		6.70E-05 15		011
●4833.7898	0	16 0 16 17 0 17		1.09E-04 4		011	4898.56697	-17	1 2 1 1 1 3 1 1 2		6.40E-04 3		011
4834.5972	-1	7 0 7 8 2 6		1.31E-04 4		011	4899.11045	29	12 2 11 13 2 12		6.25K-04 3		011
4834.9609	-4	4 2 2 5 4 1		8.37E-05 10		011	4899.25471	-6	12 4 9 1 3 4 1 0		1.75E-04 15		011
●4835.2999	385	6 5 2 7 6 1		1.43E-03 5		011	4899.3218	-33	1 2 0 1 2 1 3 1 1 3		5.80E-04 10		011
4835.8288	5	7 1 7 8 2 6		2.28E-04 2		011	4899.3460	-6	12 0 12 13 0 13		1.50E-03 6	2.91	011
4836.7716	8	12 3 9 13 4 10		2.87E-05 15		011	4899.3660	7	12 1 1 2 1 3 1 1 3		1.50E-03 6	2.91	011

Table 3. continued

observed position	0-c	upper			lower			observed strength	R	band	observed position	0-c	upper			lower			observed strength	R	band							
		J	K <sub>a</sub>	Kc	J	K <sub>a</sub>	Kc						J	K <sub>a</sub>	Kc	J	K <sub>a</sub>	Kc										
4899.3905	64	12	1	12	13	0	13	5.808-04	10	011	4930.74553	4	1	0	1	0	1	0	1	0	1	1	2.63E-03	4	6.65	011		
4899.9351	5	4	1	3	5	3	2	3.25E-04	7	011	4931.01383	23	10	2	9	1	1	1	1	0			8.95E-04	2		011		
4899.9486	4	12	2	11	13	1	12	2.60E-04	10	01)	4931.92349	-2	7	2	5	7	4	4					1.06E-04	10		011		
4901.93892	11	9	2	7	10	3	8	5.85E-04	3	011	4932.88200	38	9	2	7	1	0	2	8				4.40E-03	3	2.89	011		
4902.70371	11	11	3	8	12	3	9	6.41E-04	3	011	●4932.9922	-12	11	7	5	12	7	6					5.45E-05	10		011		
4902.8344	97	12	5	7	13	5	8	6.80E-05	10	011	4934.05640	28	9	3	6	1	0	3	7				3.30E-03	3	3.00	011		
4904.25683	27	12	5	8	13	5	9	7.1 OR-05	10	011	4934.5442	101	7	0	7	8	0	8					6.18E-05	4		021H		
4905.7244	52	7	0	7	7	3	4	5.25E-05	15	011	4934.62920	3	4	0	4	5	2	3					9.38E-04	2	3.17	011		
4905.7600	-25	5	2	4	5	4	1	6.7814-05	15	011	4934.9632	-91	7	4	4	8	4	5					1.1 OE-05	15		021H		
4905.9020	1	5	0	5	6	2	4	5.84E-04	5	011	4935.0413	29	5	0	5	5	3	2					9.50E-05	10		011		
4906.22753	-27	11	2	9	12	2	10	8.65 E-04	5	2.84	011	4935.13912	13	10	5	5	11	5	6				4.20E-04	4		011		
4906.9556	18	7	1	7	7	3	4	8.30E-05	6	011	4935.2163	39	7	1	7	8	1	8					6.15E-05	4		021H		
4907.42623	0	8	2	6	9	3	7	1.04E-03	3	011	4935.30006	-3	4	2	3	5	3	2					5.70E-03	2	3.55	011		
4908.47588	-46	12	3	10	13	2	11	7.35E-05	3	01)	4935.5225	20	10	5	6	11	5	7					4.18E-04	3		011		
4909.43676	0	11	4	7	12	4	8	4.19E-04	5	011	4936.1159	-48	7	1	7	8	0	8					1.65E-05	15		021H		
4909.79711	17	5	1	5	6	2	4	1.33E-03	3	4.04	011	4936.7988	-24	6	1	5	7	1	6					6.90E-05	3		021H	
4910.2589	44	13	0	13	13	1	12	2.15E-05	15	011	4938.93595	-1	5	1	s	5	3	2					1.53E-04	3		011		
4910.2797	3	13	1	13	13	1	12	3.196-05	15	011	4940.2310	31	8	2	6	8	4	5					9.60E-05	6		011		
4910.8424	0	12	6	6	13	6	7	3.20E-05	15	011	4940.28769	-11	9	1	8	1	0	1	9				6.4033-03	3	2.84	011		
4910.9739	49	12	6	7	13	6	8	3.82E-05	15	011	4940.93450	3	4	1	4	5	2	3					2.68E-03	3	3.69	011		
4911.34293	-2	11	1	10	12	2	11	4.64E-04	3	011	4941.55387	-6	4	2	2	5	3	3					6.12E-03	3	3.51	011		
4911.84377	-8	3	1	2	4	3	1	2.41E-04	2	011	4941.68717	-18	11	0	1	1	1	1	2	1	0			1.51E-04	3		011	
4912.08483	-1	4	3	2	5	4	1	4.81E-03	2	3.20	011	4942.3627	1	6	3	3	7	3	4					4.44 E-05	5		021H	
4912.33120	8	4	3	1	5	4	2	4.8114-03	2	3.18	011	4942.84120	28	9	2	8	1	0	2	9				6.1 OE-03	4	2.78	011	
4912.43617	-5	11	3	9	12	3	10	7.73E-04	4	011	4942.9460	-50	4	0	4	4	3	1					6.17E-05	3		011		
4912.85124	1	11	1	10	12	1	11	1.48E-03	4	2.80	011	4943.21920	-12	9	4	5	1	0	4	6				1.82E-03	2	2.79	011	
4913.62710	5	7	2	5	8	3	6	1.75E-03	3	4.30	011	●4943.6376	-298	6	5	1	6	6	0					2.6813-04	5		011	
4913.80257	0	11	2	10	12	2	11	1.47E-03	3	2.80	011	4943.8715	-31	6	2	5	7	2	6					5.828-05	5		021H	
4914.36057	-2	11	4	8	12	4	9	4.07E-05	9	011	●4944.1216	-132	7	5	3	7	6	2					3.21E-04	4		011		
4914.8690	61	8	2	7	9	2	8	2.49E-05	10	021H	4944.33760	14	1	1	0	1	1	1	1	1	0			1.32E-04	5		011	
4915.01125	-57	2	1	2	3	3	1	9.1 OB-05	4	011	4944.42422	7	11	1	1	1	1	1	1	0				1.47E-04	4		011	
4915.04943	3	11	0	11	12	1	12	1.31E-03	5	011	4944.76658	-10	8	5	4	8	6	3					1.23E-04	10		011		
4915.09727	14	11	0	11	12	0	12	3.00E-03	5	2.73	011	4944.7924	39	8	5	3	8	6	2					1.33E-04	10		011	
4915.13606	-3	11	1	11	12	1	12	2.90E-03	3	2.64	011	4944.9202	3	6	3	4	7	3	5					3.35E-05	10		021H	
4915.18385	3	11	1	11	12	0	12	1.28E-03	5	011	4945.12715	5	9	4	6	1	0	4	7					1.85E-03	4	2.73	011	
4915.31092	7	11	2	10	12	1	11	4.81E-04	3	011	4945.3725	-112	1	3	2	1	2	1	3	3	1	1			2.19E-05	15		011
4916.35540	-11	5	2	4	6	3	3	3.5744-03	3	3.79	011	4945.57294	14	9	0	9	1	0	1	1	0			4.22E-03	2	5.80	011	
4917.6111	-41	5	2	3	5	4	2	6.63E-05	7	011	4945.60218	-49	9	5	5	9	6	4					7.95E-05	3		011		
4918.00380	41	10	3	7	11	3	8	1.47E-03	3	2.91	011	4945.75981	16	9	0	9	1	0	0	1	0			1.1 OE-02	5	2.69	011	
4919.08093	6	11	5	6	12	5	7	1.97E-04	6	011	4945.91081	12	9	1	9	1	0	1	1	0				1.11E-02	2	2.72	011	
4919.30053	3	10	2	8	11	2	9	2.1 OE-03	3	2.97	011	4946.09766	12	9	1	9	1	0	0	1	0			4.20E-03	3	5.77	011	
4919.8466	16	11	5	7	12	5	8	1.89E-04	3	011	4946.15971	0	8	1	7	9	2	8					2.62E-03	3	5.35	011		
4919.8784	-57	8	0	8	9	1	9	1.63E-05	15	021H	4946.6376	-109	1	0	5	6	1	0	6	5				4.23E-05	10		011	
4920.3639	3	8	0	8	9	0	9	3.826-05	10	021H	4946.7623	39	6	0	6	7	1	7					6.16E-05	3		021H		
4920.7381	-8	8	1	8	9	1	9	4.07E-05	10	021H	4946.9990	69	1	0	5	5	1	0	6	4				4.86E-05	10		011	
4921.11544	-8	6	2	4	7	3	5	2.80E-03	3	4.00	011	4947.14998	19	8	2	6	9	2	7					9.03E-03	4	2.98	011	
●4922.45096	89	7	6	1	7	7	0	7.1 OB-05	8	011	4947.8533	29	1	1	5	7	1	1	6	6				2.39E-05	15		011	
●4922.9882	41	8	6	3	8	7	2	5.848-05	2	011	4948.3930	-14	6	0	6	7	0	7					9.52E-05	10		021H		
4923.2031	-47	7	1	6	8	1	7	4.27E-05	7	02114	●4948.46500	19	1	0	7	3	1	1	7	4				1.01E-04	9		011	
*4923.6650	436	9	6	4	9	7	3	4.15E-05	7	011	4949.25179	-1	4	1	4	4	3	1					1.30E-04	2		011		
4923.90365	-17	2	1	1	3	3	0	1.03E-04	3	011	4949.8394	-6	1	0	3	8	1	2	9					2.73E-04	2		011	
4924.11146	47	10	1	9	11	2	10	9.45E-04	2	011	4950.13209	0	1	3	5	8	1	3	6	7				3.33B-05	15		01)	
●4924.5097	-383	10	6	4	10	7	3	2.82E-05	15	011	4950.74887	4	8	3	5	9	3	6					6.15E-03	3	2.85	011		
4925.07919	-22	6	1	6	6	3	3	1.28E-04	5	011	4951.0724	53	9	5	4	1	0	5	5					8.80E-04	4		011	
4925.81672	-8	12	1	12	12	2	11	5.80E-05	5	011	4951.1317	35	5	1	4	6	1	5					1.01E-04	4		021H		
4926.37397	6	10	4	6	11	4	7	9.50E-04	5	2.98	011	4951.24530	-16	9	5	5	1	0	5	6				8.60E-04	5	2.70	011	
4926.50583	0	11	6	5	12	6	6	8.30E-05	3	011	4952.55296	-15	3	2	2	4	3	1					7.80E-03	3	3.21	011		
4926.5728	18	11	6	6	12	6	7	8.27E-05	3	011	4953.52189	-6	8	1	7	9	1	8					1.17E-02	3	2.79	011		
4926.76124	14	10	1	9	11	1	10	3.20E-03	3	2.83	011	4953.82901	-56	2	1	1	3	2	2					2.31E-05	15		021H	
4927.02132	4	10	3	8	11	3	9	1.76E-03	4																			



Table 3. continued

observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength	%	R	band	observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength	%	R	band
4959.0059	-44	11 2 9	11 4 8	5.08E-05	15		011	4985.11660	-22	8 0 8	8 2 7	1.00E-03	3	3.58	011
4959.3431	14	5 3 2	6 3 3	4.00E-05	6		0211	4985.26655	-26	1 0 3 8	1 0 4 7	2.40E-04	3		011
4959.76246	-21	8 4 4	9 4 5	3.33E-03	2	2.69	011	4985.76927	-6	8 1 8	8 2 7	1.21E-03	2	2.34	011
4960.27230	-7	8 0 8	9 1 9	6.88E-03	3	5.55	011	4985.81210	-20	3 2 1	4 2 2	9.80E-05	8		021H
4960.63515	-2	8 0 8	9 0 9	1.93E-02	2	2.73	011	4986.39237	17	6 2 5	7 2 6	2.81E-02	2	2.72	011
4960.78131	14	8 4 5	9 4 6	3.38E-03	2	2.69	011	4986.62225	2	6 1 5	6 3 4	6.66E-04	2		011
4960.92507	19	8 1 8	9 1 9	1.92E-02	2	2.72	011	4987.38486	-6	6 3 4	7 3 5	1.65E-02	2	2.70	011
4961.28784	16	8 1 8	9 0 9	6.74E-03	4	5.44	011	4987.63655	-11	8 1 7	8 3 6	5.77E-04	4		011
4961.5377	-16	10 0 10	10 1 9	3.14E-04	3		011	4988.00446	-6	9 3 7	9 4 6	4.50E-04	3		011
4961.70984	-12	1 0 1 1 0	1 0 1 9	3.24E-04	2		011	4988.05237	-3	6 0 6	7 1 7	1.34E-02	3	4.77	011
4961.9363	75	5 0 5	6 0 6	1.1 OE-04	5		0211	4988.37288	-10	7 1 6	7 3 5	6.95E-04	3		011
4962.15911	37	7 2 5	8 2 6	1.618E-02	2	2.92	011	●4988.97821	-10	7 6 2	8 6 3	1.36E-03	3	2.36	011
4963.70942	0	6 1 5	7 2 6	5.08E-03	3	4.39	011	4989.33662	6	6 0 6	7 0 7	4.60E-02	2	2.71	011
●4963.93622	-35	9 7 3 1	0 7 4	1.83E-04	10		011	4989.57110	-19	8 3 6	8 4 5	7.81E-04	2	2.18	011
4964.2036	0	5 5 0	6 5 1	3.78E-05	15		021f	4990.01460	2	4 3 2	4 4 1	1.36E-03	3	2.13	011
4964.65767	1	8 2 7	9 1 8	2.43E-03	3	5.26	011	4990.29724	-16	6 1 6	7 1 7	4.63E-02	3	2.76	011
4966.06232	11	5 4 2	5 5 1	4.90E-04	4		011	4990.39887	-2	6 3 4	6 4 3	1.48E-03	10	2.02	011
4966.08230	-6	5 4 1	5 5 0	4.90E-04	4		011	4990.47943	-2	3 1 2	4 2 3	9.00E-03	3	3.40	011
4966.2356	9	4 1 3	5 1 4	1.40E-04	10		021f	4990.97070	-13	2 1 2	3 2 1	7.33E-03	3	3.18	011
4966.49594	0	6 4 3	6 5 2	5.46E-04	4	1.87	011	4991.0488	-37	9 2 8	9 3 7	6.96E-04	3	2.28	011
4966.59601	10	6 4 2	6 5 1	6.20E-04	4	2.11	011	4991.12667	-10	5 3 2	5 4 1	1.73E-03	3	2.10	011
4966.71443	-17	7 1 6	8 1 7	2.11E-02	3	2.89	011	4991.58167	11	6 1 6	7 0 7	1.33E-02	3	4.77	011
4966.90924	-5	8 5 3	9 5 4	1.40E-03	4	2.47	011	4992.1074	61	3 1 3	4 1 4	2.1 OE-04	10		021H
4966.98503	6	8 5 4	9 5 5	1.42E-03	4	2.51	011	4992.15350	-12	6 4 2	7 4 3	7.80E-03	3	2.60	011
4967.0926	-45	7 4 4	7 5 3	4.65E-04	3		011	4992.33856	-2	6 4 3	7 4 4	7.98E-03	5	2.65	011
4967.44651	5	7 4 3	7 5 2	4.62E-04	4	1.85	011	4992.89717	-3	6 3 3	6 4 2	1.59E-03	10	2.11	011
4967.81906	26	7 3 4	8 3 5	1.09E-02	3	2.87	011	4993.6483	7	11 2 10	1 1 2 9	1.36E-04	4		011
4967.90142	-1	3 1 3	4 2 2	4.98E-03	3	3.54	011	*4994.88303	-5	7 7 0	8 7 1	2.78E-04	3		011
4968.37047	4	1 1 1 1 0	1 1 3 9	1.26E-04	3		011	4995.74575	10	1 0 1	2 2 0	3.50E-04	4		011
4968.4030	13	4 2 2	5 2 3	1.08E-04	3		021f	4996.00422	10	7 3 4	7 4 3	1.85E-03	4	3.21	011
496 8.60629	-10	9 4 6	9 5 5	2.0013-04	3		011	4997.15275	-3	8 1 8	8 1 7	1.13E-03	2	3.51	011
4968.6578	-56	8 3 5	9 5 4	3.50E-05	15		200	4997.25850	-8	7 0 7	7 2 6	1.65E-03	5	3.60	011
4968.81336	10	2 2 1	3 3 0	1.03E-02	2	3.08	011	4998-1999	-8	2 1 1	3 1 2	1.05E-04	6		021H
4968.8372	106	8 4 4	8 5 3	2.63E-04	15		011	*4998.41798	53	6 5 1	7 5 2	5.75E-03	4	2.52	011
4969.23722	-4	2 2 0	3 3 1	1.03E-02	5	3.07	011	4998.49008	-4	7 1 7	7 2 6	2.1 OE-03	2	2.37	011
●4969.4163	-50	9 8 2 1	0 8 3	4.47E-05	15		011	4998.77231	-6	8 2 7	8 3 6	1.27E-03	2	2.29	011
4969.6238	25	1 1 4 8	1 1 5 7	5.34E-05	15		011	4999.0329	28	6 3 4	7 5 3	1. 01E-04	3		200
4970.5681	-85	4 0 4	5 1 5	9.20E-05	6		0211	4999.4828	-45	3 1 3	4 0 4	3.29E-05	15		021H
4970.82910	-95	11 2 1 0	1 1 3 9	2.09E-04	3		011	5000.7480	-13	8 3 5	8 4 4	8.1 OE-04	4	2.11	011
4971.09234	-18	9 4 5	9 5 4	1.97E-04	4		011	5000.83527	-3	5 0 5	6 1 6	1.69E-02	3	4.57	011
4971.59280	50	9 0 9	9 2 8	6.55E-04	6		011	5001.14370	12	5 2 4	6 2 5	3.96E-02	2	2.74	011
4971.79227	26	7 2 6	8 2 7	1.85E-02	3	2.75	011	5001.3097	-1	1 0 4 7	1 1 3 8	5.52E-05	18		011
4971.94996	-9	5 1 4	6 2 5	8.19E-03	15	5.06	011	5001.5661	5	2 1 1	3 2 2	1.00E-02	10	3.22	011
4971.96979	3	7 3 5	8 3 6	1.02E-02	15	2.56	011	5001.72197	-6	5 3 2	6 3 3	2.19E-02	3	2.70	011
4972.73135	1	9 3 7	1 0 2 8	4.48E-04	3		011	5002.90177	-14	6 2 5	7 1 6	4.26E-03	3	4.82	011
4973.16867	5	1 2 1 1 1 1 2	2 1 0	6.60E-05	10		011	5002.97419	5	5 3 3	6 3 4	2.224? -02	5	2.71	011
*4973.3864	-55	8 6 3	9 6 4	1.04E-03	3		011	5003.13624	1	5 0 5	6 0 6	6.32E-02	3	2.71	011
4973.6439	-15	4 2 3	5 2 4	9.30E-05	10		0211	5004.2117	-28	2 2 1	3 2 2	7.80E-05	8		02 1H
4974.4788	3	7 0 7	8 1 8	9.90E-03	3	5.08	011	●5004.5566	-19	6 6 1	7 6 2	1.3 8E-03	10	2.47	011
4975.17017	3	7 0 7	8 0 8	3.08E-02	2	2.70	011	5004.73033	8	5 1 5	6 1 6	6.24E-02	3	2.73	011
4975.3140	-20	4 0 4	5 0 5	1.53E-04	10		021f	5004.83372	-12	7 2 6	7 3 5	2.12E-03	2	2.33	011
4975.71035	4	7 1 7	8 1 8	3.06E-02	2	2.70	011	5006.3064	-40	2 1 2	3 1 3	1.52E-04	5		021H
4976.06682	-4	7 4 3	8 4 4	5.53E-03	3	2.68	011	5006.98947	41	9 3 6	9 4 5	4.84E-04	10		011
4976.40168	0	7 1 7	8 0 8	9.92E-03	3	5.11	011	5007.03124	6	5 1 5	6 0 6	1.64E-02	2	4.55	011
4976.53667	12	7 4 4	8 4 5	5.59E-03	3	2.69	011	5008.0813	76	5 4 1	6 4 2	1.00E-02	4	2.76	011
4977.4426	53	10 1 9	1 0 3 8	2.74E-04	2		011	5008.14009	-12	5 4 2	6 4 3	9.68E-03	4	2.67	011
4977.89692	19	6 2 4	7 2 5	2.60E-02	2	2.86	011	5008.38468	-20	1 0 1 9	1 0 2 8	4.67E-04	3		011
4978.49325	6	2 0 2	3 2 1	8.49E-04	2	3.19	011	5009.10895	13	4 1 3	5 1 4	6.54E-02	3	2.83	011
4978.85768	-9	4 1 3	4 3 2	3.03E-04	4		011	5009.30490	-11	6 2 5	6 3 4	3.02E-03	4	2.28	011
4978.95457	3	9 0 9	9 1 8	6.63E-04	3	2.26	011	5009.86750	2	6 1 6	6 2 5	3.43E-03	4	2.47	011
4979.29240	-3	9 1 9	9 1 8	6.39E-04	3		011	5010.80147	0	1 1 1	2 2 0	9.53E-03	3	2.98	011
●4979.40941	1	8 7 1	9 7 2	2.77E-04	3		011	5011.22522	22	4 2 2	5 2 3	4.77E-02	2	2.80	011
4979.56055	-2	1 1 4 7	1 1 5 6	5.97E-05	10		011	5012.35309	-15	5 2 4	5 3 3	3.99E-03	3	2.38	011
4980.21901	-12	6 1 5	7 1 6	3.32E-02	2	2.83	011	5012.75918	3	4 0 4	5 1 5	1.83E-02	2	4.14	011
4980.70848	-3	4 1 3	5 2 4	8.14E-03	3	3.82	011	5013.76831	2	7 0 7	7 1 6	2.63E-03	7	2.55	011
4981.69440	-17	1 0 2 9	1 0 3 8	3.44E-04	10		011	5013.99821	-12	1 0 3 7	1 0 4 6	2.84E-04	15		011
4982.0100	10	3 1 2	4 1 3	1.54E-04	3		021f	5014.1205	59	1 1 0	2 2 1	8.57E-03	10	2.44	011
4982.68742	-10	7 5 2	8 5 3	2.20E-03	3	2.49	011	5014.22269	-12	4 2 3	4 3 2	4.23E-03	2	2.39	011
4982.71838	-11	7 5 3	8 5 4	2.21E-03	3	2.50	011	5014.9512	-35	1 1 0	2 1 1	1.15E-04	4		021H
4983.98474	-2	9 1 8	9 3 7	4.1 OE-04	4		011	5014.99973	-10	7 1 7	7 1 6	1.99E-03	6	3.31	011
4984.2660	4	7 3 4	8 5 3	5.26E-05	15		200	5015.20657	-32	3 2 2	3 3 1	3.21E-03	4	2.43	011
4984.90567	-6	6 3 3	7 3 4	1.62E-02	3	2.72	011	5015.81447	0	5 0 5	5 2 4	2.66E-03	4	3.39	011

Table 3. continued

observed position	0-c	upper			lower			observed strength %s	R	band	observed position	0-c	Upper			lower			observed strength %s	R	band			
		J	K <sub>a</sub>	K <sub>c</sub>	J	K <sub>a</sub>	K <sub>c</sub>						J	K <sub>a</sub>	K <sub>c</sub>	J	K <sub>a</sub>	K <sub>c</sub>						
5016.07370	15	4	2	3	5	2	4	4.83E-02	3	2.72	011	5054.6735	-16	4	3	2	4	3	1	9.20E-05	10	021H		
5016.67784	-7	4	0	4	5	0	5	8.08E-02	2	2.75	011	5054.8871	-22	3	3	1	3	3	0	1.53E-04	7	021H		
5017.11333	-7	3	2	1	3	3	0	3.23E-03	2	2.40	011	5054.9458	38	3	3	0	3	3	1	1.85E-04	4	021H		
5017.5266	-28	5	3	3	6	5	2	2.45E-05	15		200	5055.0743	-13	4	3	1	4	3	2	9.09E-05	4	021H		
5017.5804	3	1	0	1	2	0	2	1.4613-04	3		021H	5055.64045	-1	4	0	4	4	1	3	1.24E-02	3	2.77 011		
5017.8587	2	5	1	5	4	3	2	2.65E-05	10		011	5055.9572	21	4	2	2	4	2	3	6.49E-05	6	021H		
5018.16380	0	4	3	1	5	3	2	2.46E-02	2	2.68	011	5056.1090	-27	7	2	5	8	4	4	5.04E-05	10	200		
5018.67788	5	4	3	2	5	3	3	2.44E-02	2	2.64	011	5056.70530	-1	2	1	2	3	0	3	1.17E-02	4	3.68 011		
5019.06446	1	4	1	4	5	1	5	7.77E-02	2	2.75	011	5056.86170	6	1	1	0	2	1	1	5.31E-02	2	2.73 011		
5019.54230	-3	4	2	2	4	3	1	4.30E-03	3	2.31	011	5057.5479	64	0	0	0	9	2	7	4.56E-05	10	200		
5019.70935	-7	5	1	5	5	2	4	4.73E-03	3	2.40	011	5057.6247	-16	2	1	1	2	1	2	4.05E-05	15	02 1H		
5020.50140	-5	7	3	5	8	2	6	9.35E-04	4		011	5058.1858	9	9	4	8	1	0	3	8	1.01E-04	5	011	
5020.5375	-63	1	1	1	2	1	2	1.04E-04	4		021H	5058.84150	-12	1	0	1	2	0	2		7.82E-02	2	2.75 011	
5020.59021	-12	1	1	3	8	1	4	7	1.37E-04	10		5059.73135	11	0	0	0	1	1	1	9.88E-03	2	3.07 011		
5021.07733	19	6	1	6	5	3	3	4.35E-05	15		011	5060.3602	-50	7	4	4	7	4	3	1.95E-05	15	021H		
5021.58202	-8	4	0	4	4	2	3	2.53E-03	3	3.46	011	5060.5526	-14	6	4	3	6	4	2	5.12E-05	15	021H		
5022.98322	1	4	1	4	5	0	5	1.75E-02	3	4.25	011	5060.7180	-9	6	4	2	6	4	3	4.33E-05	15	021H		
5023.44416	-3	5	2	3	5	3	2	4.40E-03	4	2.38	011	5061.1481	-1	5	1	4	4	3	1	1.14E-04	3	011		
5023.5120	1	5	2	4	6	1	5	4.50E-03	5	4.50	011	5061.61512	7	7	2	6	7	2	5	3.50E-03	2	2.88 011		
5023.70838	"6	9	1	8	9	2	7	1.22E-03	10	2.78	011	5063.94297	4	3	0	3	3	1	2	1.72E-02	3	2.95 011		
5024.02200	-3	3	0	3	4	1	4	1.87E-02	3	3.90	011	5065.2474	33	3	2	2	4	1	3	3.78E-03	10	4.86 011		
5024.53810	29	3	1	2	4	1	3	7.57E-02	3	2.78	011	5066.4614	-45	3	1	2	3	1	3	3.78E-05	10	021H		
5025.01500	-26	3	0	3	3	2	2	1.70E-03	3	3.49	011	5066.93978	8	5	3	3	6	2	4	1.23E-03	3	011		
5025.4235	-48	1	2	3	9	1	2	4	8	7.25E-05	15	5067.0434	-59	8	3	5	9	2	8	2.25E-04	10	011		
5025.8414	28	9	2	7	1	0	4	6	2.95E-05	15	200	5068.1580	27	5	3	3	4	4	0	8.80E-05	4	011		
5026.6320	34	2	0	2	2	2	1	6.50E-04	10		011	5069.37350	11	2	0	2	2	1	1	1.7733-02	3	2.87 011		
5026.82283	-7	9	4	6	1	0	3	7	1.37E-04	4		5069.6684	74	7	3	4	8	2	7	4.61E-04	4	011		
5027.2294	-90	1	3	3	1	0	1	3	4	9	011	5069.7794	-2	6	2	4	7	4	3	1.60E-04	10	200		
5027.88723	-17	4	1	4	4	2	3	6.22E-03	4	2.53	011	5070.0304	29	*	4	4	9	3	7	1.93E-04	4	011		
5028.3284	-10	3	2	1	4	2	2	5.00E-02	5	2.75	011	5071.13506	-12	3	0	3	2	2	0	2.41E-04	3	011		
5029.1749	35	1	0	1	1	1	0	1.89E-05	10		021H	5072.51847	11	1	0	1	1	1	0	1.36E-02	3	2.85 011		
5029.4381	2	7	2	6	8	4	5	4.40E-05	15		200	5073.89733	-11	1	1	1	2	0	2	6.45E-03	3	3.68 011		
5029.99078	-11	6	0	6	6	1	5	4.62E-03	5	2.58	011	5074.03148	-12	0	0	0	1	0	1	4.53E-02	2	2.73 011		
5030.24794	-8	3	0	3	4	0	4	9.40E-02	3	2.80	011	5074.3026	-19	5	2	4	6	4	3	7.04E-05	15	200		
5030.6903	31	1	1	2	9	1	1	3	8	2.31E-04	5	011	5075.9324	49	7	4	4	6	5	1	3.58E-05	15	011	
5030.7729	17	9	2	8	9	2	7	7.90E-04	6		011	5076.2940	51	7	4	3	6	5	2	2.98E-05	15	011		
5031.18865	-6	3	2	2	4	2	3	5.00E-02	4	2.70	011	5076.440411	5	6	3	3	7	2	6	7.22 B-M	5	011		
5032.23577	-12	6	1	6	6	1	5	3.42E-03	4	3.13	011	5076.65891	6	4	2	3	3	3	0	2.88E-04	3	011		
5033.2860	59	7	2	5	7	3	4	3.20E-03	10	2.77	011	5077.4170	26	11	3	10	14	3	11	5.54E-05	10	200		
5034.2704	-5	3	3	0	4	3	1	1.90E-02	6	2.57	011	5078.18944	2	9	1	?				* I *	1.12E-03	2	2.71 011	
5034.34853	-3	3	1	3	3	2	2	6.40E-03	4	2.48	011	5078.8855	10	2	0	2	1	0	1	1.72E-04	6	021H		
5034.42724	-10	3	3	1	4	3	2	1.92E-02	3	2.59	011	5079.2791	99	9	5	5	1	0	4	6	6.44E-05	10	011	
5035.16690	-10	2	0	2	3	1	3	1.69E-02	2	3.57	011	5079.72679	2	6	1	5	5	1	2	1.93E-04	3	011		
5036.0830	15	12	3	1	0	1	2	3	9	5.32E-05	10	011	5080.4674.1	-67	3	1	1	1	1	2	6.67E-04	3	2.11 011	
5036.16840	5	8	1	7	8	2	6	2.33E-03	5	2.56	011	5081.85115	12	2	1	2	2	1	1	2.99E-02	2	2.76 011		
5036.42360	-5	1	0	2	8	1	0	3	7	5.44E-04	3	011	5082.02456	25	5	2	4	5	2	1	1.49E-02	2	2.00 011	
5036.99847	3	8	2	6	8	3	5	2.00E-03	3	2.66	011	5082.19607	-4	4	2	2	1	1	1	1.08E-04	3	011		
5038.33970	0	9	2	7	9	3	6	1.13E-03	2	2.67	011	5062.9297	35	2	1	1	1	1	0	1.10E-04	10	021H		
5039.10940	10	2	1	2	2	2	1	4.90E-03	4	2.50	011	5083.84031	64	7	4	1	8	1	6	1.25E-04	1	011		
5039.4022	-34	5	2	4	5	2	3	2.27E-05	15		021H	5083.8972	47	9	5	4	10	4	7	4.80E-05	15	011		
5039.58125	-7	3	1	3	4	0	4	1.60E-02	2	3.97	011	5084.0311	34	6	3	4	5	4	1	1.44E-04	10	011		
5040.49387	15	2	1	1	3	1	2	7.47E-02	2	2.78	011	5084.13709	14	7	0	7	6	2	6	2.09E-04	3	011		
5041.2936	-21	4	1	3	3	3	0	4.44E-05	15		011	5085.2921	46	4	1	1	4	6	4	2.96E-05	15	02km		
5044.47372	-14	4	2	3	5	1	4	4.40E-03	2	4.51	011	5085.3687	21	7	1	7	6	2	6	9.21E-05	10	02,		
5045.1540	-19	7	1	6	7	2	5	4.50E-03	10	2.66	011	5085.40317	1	2	2	1	1	1	2	1.75E-03	1	4.10 011		
5045.19625	-3	2	2	0	3	2	1	3.80E-02	3	2.74	011	5085.9069	-33	1	2	4	9	1	>	4	0	7.00E-05	4	0.8
5045.5143	8	4	2	3	4	2	2	1.32E-04	4		021H	5086.33888	-16	8	3	6	8	3	5	3.01E-03	4	1.00 011		
5045.8432	-12	1	1	1	1	1	0	1.28E-04	4		021H	5												

Table 3. continued

observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength	%	R	band	observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength	%	R	band
5093.00688	11	3 0 3	2 0 2	2.50E-04	10		021H	5114.7470	41	5 1 5	6 3 4	9.92E-05	6		200
5093.23777	19	1 1 0	1 1 1	6.33E-02	3	2.72	011	5115.20921	-1	1 2 2	1 0 1 3 2 1 1	2.26E-04	4		200
5093.33446	-28	2 2 0	2 2 1	1.01E-01	2	2.88	011	5115.25214	-2	5 1 5	4 1 4	2.25E-04	4		021H
5093.57448	-13	6 2 4	7 1 7	2.47E-04	5		011	5115.85762	-6	7 5 3	8 4 4	1.04E-04	10		011
5093.70053	5	6 4 3	7 3 4	3.70E-04	4		011	5116.07455	-6	4 2 2	3 2 1	1.1413-04	8		021H
5093.78243	3	3 2 1	4 1 4	1.34E-03	3	3.96	011	5116.19117	6	3 1 2	3 0 3	1.91E-02	3	3.11	011
5094.1226	-19	4 2 3	5 4 2	4.04E-05	15		200	5117.25706	-2	9 3 6	9 3 7	1.13E-03	4	2.48	011
5094.62603	1	6 3 4	6 3 3	1.28E-02	3	2.64	011	5117.9624	-41	4 1 3	4 1 4	1.05E-02	5	2.69	011
5094.77568	5	3 2 1	3 2 2	5.13E-02	3	2.66	011	*5118.0256	-93	1 1 7	4 1 1 7 5	1.24E-04	10		011
5095.0541	36	4 2 2	4 1 3	3.85E-05	10		021H	●5118.0661	-62	1 0 7	3 1 0 7 4	3.22E-04	10		011
5095.4688	-31	4 0 4	3 1 3	2.01E-05	10		021H	●5118.1043	10	9 7 3	9 7 2	7.84E-04	10		011
5095.61400	-8	7 1 6	6 3 3	2.37E-04	3		011	●5118.14511	-50	0 7 2	8 7 1	1.63E-03	8		011
5096.07872	0	5 3 3	5 3 2	2.50E-02	3	2.65	011	●5118.18829	43	7 7 1	7 7 0	3.50E-03	4		011
5096.66614	-9	4 3 2	4 3 1	4.47E-02	2	2.60	011	●5118.22705	8	2 1 2	1 1 1	6.08E-02	5	2.59	011
5096.86322	-16	3 3 1	3 3 0	7.84E-02	2	2.58	011	5118.3649	10	13 1 12	14 1 13	1.53E-04	15		200
5096.92411	-12	3 3 0	3 3 1	7.87E-02	2	2.59	011	5118.4309	17	8 2 7	7 3 4	1.33E-04	15		011
5097.08640	-4	4 3 1	4 3 2	4.46E-02	2	2.59	011	5118.7899	7	13 2 12	14 2 13	1.65E-04	7		200
5097.71949	-27	5 3 2	5 3 3	2.53E-02	2	2.69	011	5118.87118	-82	1 4 1 1 4	1 5 1 1 5	8.1 OE-04	6		200
5098.17802	9	4 2 2	4 2 3	2.79E-02	2	2.64	011	5118.95600	-4	4 1 3	3 2 2	2.07E-03	4	1.94	011
5098.59506	-5	3 1 2	2 2 1	1.09E-03	4	2.05	011	5120.2980	6	1 2 4	8 1 2 4 9	4.98E-05	10		011
5098.82820	4	2 1 1	2 1 2	3.03E-02	2	2.68	011	5120.6205	-88	9 2 8	8 3 5	4.89E-05	15		011
5098.9371	-16	4 3 1	5 2 4	1.01E-03	4		011	5121.6591	-12	1 2 3	1 0 1 3 3 1 1	2.15E-04	3		200
5099.35315	-9	6 3 3	6 3 4	1.30E-02	3	2.65	011	5121.9952	13	1 1 3	8 1 2 3 9	4.11E-04	4		200
5099.6980	34	14 2 13	15 2 14	7.45E-05	6		200	5122.27753	16	3 0 3	2 1 2	9.80E-03	6	2.48	011
5099.75578	-6	9 4 6	9 4 5	1.46E-03	3	2.63	011	*5122.7037	13	1 1 8	3 1 1 8 4	6.00E-05	10		011
5099.90382	-77	8 3 6	8 5 3	1.02E-04	10		200	●5122.75760	-64	1 0	8 2 1 0 8 3	1.43E-04	9		011
5099.9863	75	1 2 4	8 1 3 4 9	4.00E-04	6		200	●5122.8045	0	9 8 1	9 8 2	3.27E-04	9		011
5100.3488	11	7 0 7	8 2 6	1.11E-04	6		200	●5122.84654	-10	8 8 0	8 8 1	7.71E-04	8		011
5100.9654	3	8 4 5	8 4 4	3.32E-03	3	2.59	011	5124.18883	3	4 1 3	4 0 4	1.52E-02	3	3.13	011
5101.48953	-9	7 4 4	7 4 3	7.00E-03	2	2.57	011	5124.3548	45	6 2 4	5 3 3	5.00E-04	4	1.22	011
5101.69200	5	6 4 3	6 4 2	1.36E-02	3	2.51	011	5124.45881	13	2 1 1	1 1 0	6.29E-02	2	2.72	011
5101.7722	12	5 4 2	5 4 1	2.50E-02	5	2.46	011	5124.82004	-7	7 2 5	7 2 6	3.70E-03	4	2.60	011
5102.13620	7	7 4 3	7 4 4	7.00E-03	3	2.57	011	5125.5733	-23	1 )	4 7 1 2 4 8	2.49E-04	3		200
5102.36653	-38	5 2 3	4 3 2	4.96E-04	3	1.43	011	●5126.5185	.30	1 0 9	2 1 0 9 1	5.63E-05	10		011
5102.40930	-29	6 2 5	5 3 2	3.81E-04	3	1.25	011	●5126.5655	15	9 9 1	9 9 0	1.20 B-M	4		011
5102.70947	-2	7 3 4	7 3 5	6.22E-03	2	2.60	011	5127.1780	0	6 1 6	5 1 5	2.15E-04	5		021H
5102.83530	15	8 4 4	8 4 5	3.56E-03	2	2.78	011	5127.3382	63	4 3 1	5 1 4	4.85E-05	15		011
5103.6500	-52	3 1 3	2 0 2	2.53E-05	10		021H	5128.1886	-12	9 3 7	8 4 4	5.70E-05	15		011
5104.21743	-22	5 2 3	5 2 4	1.46E-02	3	2.60	011	5129.14173	16	6 0 6	5 0 5	2.17E-04	5		021H
5104.40186	16	9 4 5	9 4 6	1.3933-03	3	2.47	011	5129.7407	19	4 4 1	5 3 2	2.35E-04	8		011
5105.01463	-10	1 0 1	0 0 0	4.87E-02	2	2.70	011	5129.9948	10	11 5 6	12 5 7	1.36 B-M	3		200
5105.6650	93	1 2 5	8 1 2 5 7	6.00E-05	10		011	5130.4869	26	4 4 0	5 3 3	20E-04	6		011
5105.74925	-8	2 0 2	1 1 1	5.19E-03	2	2.55	011	5130.90606	10	5 1 4	5 1 5	216-03	4	2 61	011
5106.0756	-50	1 2 5	7 1 3 5 8	5.99E-05	7		200	5131.1182	55	11 5 7	12 5 7	20E-04	10		200
5106.5947	-13	1 1 5	7 1 1 5 6	1.94E-04	6		011	5131.61069	2	3 1 1	2 1 2	01E-01	2	2 70	011
5106.896	45	1 2 6	6 1 3 6 7	3.11E-05	7		200	5132.23614	-15	4 2 2	4 1 3	51E-02	3	3 65	011
5106.99963	-22	1 0 5	6 1 0 5 5	5.40E-04	5		011	5132.52698	-35	2 2 2	1 0 1	27E	02	2 62	011
5107.1306	14	3 1 2	3 1 3	1.55E-02	10	2.38	011	5132.61800	4	5 2 3	5 1 4	31E	02	2	011
5107.2076	-29	8 5 4	8 5 3	2.39E-03	7	2.22	011	5132.8136	-40	6 5 2	7 4 3	14E	04	5	011
●5107.3028	39	5 5 1	5 5 0	3.64E-02	5	2.20	011	5133.1068	-32	6 5 1	7 4 4	11E	04	6	011
5107.3489	46	1 0 4	6 1 0 4 7	4.66E-04	15		011	5133.2510	-46	5 3 3	4 1 2	●00E	05	10	011
5107.3766	58	9 5 4	9 5 5	1.20E-03	10		011	5133.5413	-44	11 2 9	12 9 10	6 0 9 4 4 3			200
5107.53777	-17	1 1 0	1 0 1	1.54E-02	3	3.20	011	5133.70318	-12	3 2 1	3 1 2	3 14E	02	6	1 6 0 0 0
5107.66447	-12	1 0 5	5 1 0 5 6	5.08E-04	3		011	5134.23120	5	3 0 1	2 0 2	1 17E	01	3	2 1 1 0 0 0
5107.87127	-21	6 3 4	6 5 1	7.96E-05	15		200	5134.87960	8	5 1 4	5 0 5	1 1 0 2 0 2 4		3 1 1 0 0 0	
5108.07856	8	3 3 1	4 2 2	6.14E-04	2		011	5135.51311	1	6 2 4	6 1 5	1 04E	02	5	1 0 0 0 0 0
5108.2905	-16	1 2 5	8 1 3 5 9	5.19E-05	5		200	5136.07662	15	2 2 0	2 1 1	8 6 5E	03	1	1 0 0 0 0 0
5108.3141	-20	1 1 5	6 1 1 5 7	2.12E-04	4		011	5136.70703	-16	12 1 11	13 1 12	3.80E	04	4	2 0 0 0 0 0
5108.52093	-1	8 3 5	8 3 6	2.77E-03	2	2.56	011	5138.23313	3	4 0 4	3 1 3	1.12E	02	5	2 0 0 0 0 0
5109.3565	-9	1 0 2	8 9 4 5	2.71E-05	15		011	●5138.8166	715	5 4 2	4 4 1	3.21E-05	10		04 0
5109.6053	5	1 2 5	7 1 2 5 8	7.03E-05	4		011	5138.84733	3	8 2 6	8 2 7	1.73E-03	4		2 0 0 0 0 0
5110.78185	-9	2 1 1	2 0 2	1.96E-02	3	3.10	011	5139.30448	11	3 2 2	2 2 1	4.77E-02	2		2 0 0 0 0 0
5110.9303	-45	2 2 0	3 0 3	1.47E-04	6		011	●5139.6490	50	9 6 4	9 7 3	4.37E-04	8		2 0 0 0 0 0
5111.8695	-1	1 2 4	9 13 4 10	1.1 OE-04	3		200	5139.78368	-3	5 1 4	4 2 3	2.48E-03	4	3 7 1	0 0 0 0 0 0
5112.0743	-64	7 2 6	6 3 3	2.67E-04	6		011	5139.9156	-132	7 0 7	6 0 6	1.62E-04	4		0 0 0 0 0 0
5112.4427	49	1 1 4	7 1 1 4 8	2.05E-04	10		011	5140.89572	17	3 2 1	2 2 0	4.72E-02	3	2 0 6	0 0 1 1
●5112.85356	-9	7 6 2	7 6 1	5.97E-03	6	2.02	011	5141.33675	-9	3 1 2	2 1 1	1.00E-01	3	2 0 5	0 1 1
●5112.8946	32	6 6 1	6 6 0	1.31E-02	3	2.26	011	5141.4906	49	7 1 7	6 0 6	2.31E-05	15		0 21D
5113.5568	-17	9 1 8	8 3 5	1.16E-04	3		011	5141.57829	-5	1 1 3	9 1 2 3 1 0	4.64E-04	3		2 0 0
5114.0026	-25	8 2 6	9 1 9	3.24E-05	15		011	5143.31931	-2	1 1 3	8 1 1 3 9	1.66E-04	3		0 1 1
5114.1598	-65	3 2 1	4 4 0	2.44E-05	15		200	5143.56445	0	3 1 3	2 0 2	1.47E-02	4	2.83	011
5114.5363	-28	5 4 1	6 3 4	4.18E-04	5		011	5143.73750	-10	2 2 1	2 1 2	7.15E-03	3	3.55	011

Table 3. continued

observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength %s	R	band	observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength %s	R	band
5144.53840	0	4 1 4	3 1 3	1.118-01	3	2.66 011	5174.29106	8	1 0 2 9	11 2 10	1.838-03	4	3.10 200
5145.20054	19	10 3 7	11 3 8	<b>9.73E-04</b>	4	200	5174.52560	-1	3 3 1	3 2 2	<b>5.00E-03</b>	5	3.71 011
5145.52105	-5	6 1 5	6 1 6	<b>3.63E-03</b>	4	2.51 011	5174.62113	3	5 0 5	6 2 4	<b>4.40E-04</b>	10	200
5147.29380	3	4 0 4	3 0 3	1.258-01	3	2.73 011	5175.00135	-9	5 3 3	4 3 2	<b>3.62E-02</b>	4	2.59 011
5147.7333	38	7 2 5	6 3 4	<b>4.20E-04</b>	15	1.07 011	5175.21557	0	9 5 5	1 0 5 6	<b>5.60E-04</b>	4	200
5147.8398	9	3 2 2	3 1 3	<b>8.00E-03</b>	6	2.97 011	5175.30189	6	4 3 2	4 2 3	<b>6.48E-03</b>	3	3.55 011
5148.9092	34	6 3 4	5 3 3	<b>7.00E-05</b>	10	021H	5175.70814	-2	5 3 2	4 3 1	<b>3.54E-02</b>	2	2.55 011
5149.6691	0	8 1 8	7 1 7	<b>1.16E-04</b>	5	021H	5175.9276	-5	1 0 2 8	1 0 1 9	<b>7.48E-04</b>	15	011
5149.95511	-9	5 1 4	6 3 3	2.686-04	4	200	5176.01814	9	5 2 3	4 2 2	<b>6.96E-02</b>	3	2.66 011
5150.0614	-14	9 3 6	8 4 5	<b>5.40E-05</b>	10	011	5176.8525	32	5 3 3	5 2 4	<b>6.88E-03</b>	4	3.89 011
5150.23075	0	8 2 6	8 1 7	<b>3.57E-03</b>	10	3.27 011	5177.29291	-2	7 2 6	7 1 7	<b>3.68E-03</b>	3	3.65 011
5150.5452	0	10 7 3	11 7 4	<b>7.32E-05</b>	15	200	5177.4593	55	5 2 3	5 4 2	<b>2.27E-05</b>	15	200
5150.6012	-16	6 3 3	5 3 2	<b>6.83E-05</b>	10	021H	5178.57705	-4	7 2 6	7 0 7	<b>1.72E-03</b>	3	2.37 011
5151.4508	154	7 6 1	8 5 4	<b>8.50E-05</b>	10	011	5179.07023	-3	7 0 7	6 1 6	6.65E-03	5	1.48 011
5151.7220	-36	6 2 4	6 2 3	<b>9.77E-05</b>	10	021H	5179.4134	-69	6 3 4	6 2 5	<b>5.70E-03</b>	6	3.99 011
5152.31560	34	10 2 8	11 2 9	<b>1.30E-03</b>	4	200	5179.7018	-2	5 4 2	4 4 1	<b>1.17E-02</b>	6	2.51 011
5152.9333	-104	10 5 5	11 5 6	<b>2.80E-04</b>	3	200	5179.7195	-67	5 4 1	4 4 0	1.17E-02	7	2.51 011
5153.06877	0	5 0 5	4 1 4	<b>1.11E-02</b>	4	1.91 011	5180.30177	-3	7 1 7	6 1 6	<b>7.77E-02</b>	3	2.80 011
5153.32784	-1	4 2 3	4 1 4	<b>9.57E-03</b>	10	3.64 011	5180.40226	11	7 1 6	6 2 5	<b>2.00E-03</b>	6	1.38 011
5153.44982	2	10 5 6	11 5 7	<b>2.84E-04</b>	4	200	5181.3232	33	9 3 7	1 0 3 8	2.1 OB-03	6	200
5153.59907	0	4 1 4	3 0 3	1.436-02	3	2.26 011	5181.37125	6	7 0 7	6 0 6	<b>7.80E-02</b>	3	2.77 011
5154.32105	-3	4 2 3	3 2 2	<b>6.84E-02</b>	2	2.67 011	5182.04620	10	3 2 2	2 1 1	<b>1.20E-02</b>	8	3.07 011
5154.8910	-4	7 2 6	6 2 5	<b>9.90E-05</b>	10	021H	5183.1825	-55	6 2 5	5 2 4	<b>6.52E-02</b>	3	2.80 011
5155.69200	62	2 2 1	2 0 2	<b>7.35E-04</b>	3	2.85 011	5183.7579	74	12 1 12	12 1 11	<b>3.06E-05</b>	15	200
5155.76555	.0	12 0 12	13 0 13	<b>8.32E-04</b>	4	3.03 200	5184.1260	14	1 1 4 7	1 1 3 8	<b>2.53E-04</b>	4	011
5155.79801	0	12 1 12	13 1 13	<b>8. 01E-04</b>	4	2.92 200	5186.0674	47	8 3 5	7 3 4	<b>4.65E-05</b>	10	021H
5156.00797	-5	1 1 2 1 0	1 2 2 1 1	9.1 OE-04	3	3.26 200	5186.6907	-5	8 2 6	7 2 5	<b>6.39E-05</b>	10	02 1H
51 86.96350	-22	5 1 5	4 1 4	<b>1.20E-01</b>	5	2.95 011	5186.7526	-17	2 2 0	1 0 1	<b>4.90E-04</b>	10	011
5157.0524	-23	8 3 5	8 2 6	<b>3.30E-03</b>	10	3.80 011	5187.0230	-50	9 2 7	9 4 6	<b>3.45E-05</b>	15	200
5157.88370	-1	4 1 3	3 1 2	<b>1.04E-01</b>	2	2.69 011	5187.18558	-4	8 2 7	8 1 8	<b>2.25E-03</b>	3	3.74 011
5158.15522	10	4 2 2	3 2 1	<b>6.73E-02</b>	2	2.64 011	5187.87695	-4	8 2 7	8 0 8	1.1 OB-03	3	2.36 011
5159.2952	44	5 0 5	4 0 4	1.266-01	8	2.94 011	5187.9412	-29	13 3 10	13 2 11	<b>5.50E-05</b>	5	011
5159.4907	0	7 3 4	7 2 5	<b>4.50E-03</b>	15	3.58 011	5188.18808	18	8 3 6	8 2 7	<b>2.34E-03</b>	3	3.70 011
5159.52260	4	4 3 1	3 3 0	<b>2.95E-02</b>	8	2.86 011	5188.90090	32	6 1 5	5 1 4	<b>7.95E-02</b>	3	2.74 011
5159.5533	-54	4 2 3	4 0 4	<b>2.81E-03</b>	10	2.70 011	5190.5613	-8	9 1 8	9 1 9	<b>6.46E-04</b>	5	2.29 011
5160.15425	-4	5 2 4	5 1 5	<b>7.80E-03</b>	10	3.63 011	5190.92417	-1	9 1 8	9 0 9	<b>1.27E-03</b>	4	3.70 011
5160.3119	-24	9 1 9	8 1 8	6. s56-05	10	021H	5190.97035	0	1 1 2 9	11 1 10	<b>3.30E-04</b>	9	011
5160.83208	1	7 1 6	7 1 7	<b>2.11E-03</b>	4	2.43 011	5191.0027	21	10 0 10	11 1 11	<b>1.33E-04</b>	5	200
5161.1572	-1	7 1 6	6 1 5	<b>1.18E-04</b>	5	021H	5191.0975	6	10 0 10	11 0 11	<b>4.03E-03</b>	3	3.46 200
5161.46925	17	1 0 3 8	1 1 3 9	<b>1.07E-03</b>	4	200	5191.2148	-3	10 1 10	11 1 11	3.40E-03	5	2.92 200
5161.99708	-2	9 2 7	9 1 8	<b>1.75E-03</b>	2	3.31 011	5191.27027	2	8 1 8	7 1 7	<b>5.55E-02</b>	2	2.76 011
5162.11626	3	7 1 6	7 0 7	<b>4.12E-03</b>	2	3.51 011	5191.8363	2	8 2 6	9 2 7	<b>5.25E-03</b>	10	3.26 200
5162.2036	31	6 2 5	6 4 2	<b>2.17E-05</b>	15	200	5192.0373	-44	3 2 1	2 1 2	<b>1.00E-02</b>	4	3.29 011
5163.18965	-6	5 1 5	4 0 4	<b>1.17E-02</b>	4	1.87 011	5192.1526	16	8 3 5	9 3 6	<b>3.73E-03</b>	4	3.27 200
5163.31885	5	6 3 3	6 2 4	<b>5.70E-03</b>	4	3.54 011	5192.3485	12	9 2 8	1 0 2 9	<b>3.65E-03</b>	5	3.13 200
5164.07312	7	5 2 4	5 0 5	<b>2.87E-03</b>	5	2.50 011	5192.45785	3	6 3 3	5 3 2	<b>3.46E-02</b>	3	2.58 011
5165.59520	-53	3 1 3	4 3 2	<b>9.75E-05</b>	3	200	● 5192.988	-10	8 7 1	9 7 2	3.1 OB-04	6	200
5165.95710	1	4 1 3	5 3 2	<b>2.22E-04</b>	5	200	5193.24877	2	4 2 3	3 1 2	<b>9.00E-03</b>	4	2.54 011
5166.63320	1	6 0 6	5 1 5	<b>9.20E-03</b>	5	1.70 011	5194.02550	8	6 2 4	5 2 3	<b>5.89E-02</b>	2	2.62 011
5167.39093	10	5 3 2	5 2 3	<b>6.67E-03</b>	3	3.60 011	5194.2521	-97	9 3 7	8 3 6	<b>1.78E-05</b>	15	021H
● 5167.6742	-393	6 6 0	7 5 3	2.936-05	10	011	5194.48473	15	9 3 7	9 2 8	<b>1.27E-03</b>	4	3.57 011
5167.9337	-96	5 2 4	5 4 1	2.118-05	15	200	5194.58619	-41	9 4 5	9 3 6	<b>8.51E-04</b>	10	011
5167.9869	54	7 3 4	6 3 3	6.1 OB-05	10	021H	5194.8716	-3	2 1 1	3 3 0	<b>5.86E-05</b>	15	200
5168.0597	-73	8 2 7	7 2 6	<b>8.20E-05</b>	5	021H	5195.41981	-8	6 4 3	5 4 2	<b>1.48E-02</b>	3	2.49 011
5168.20385	-3	6 2 5	6 1 6	<b>5.65E-03</b>	3	3.64 01)	5195.50458	-25	6 4 2	5 4 1	<b>1.48E-02</b>	3	2.49 011
5168.72444	38	9 3 6	1 0 3 7	2.006-03	10	200	5196.11230	49	9 2 7	8 3 6	<b>2.30E-04</b>	7	011
5168.87822	3	6 1 6	5 1 5	<b>9.73E-02</b>	2	2.76 011	5196.2921	3	8 5 3	9 5 4	<b>1.00E-03</b>	6	200
5168.97717	-7	5 2 4	4 2 3	<b>7.00E-02</b>	3	2.63 011	5196.379	-260	8 5 4	9 5 5	<b>1.05E-03</b>	8	200
5169.36810	-2	2 2 1	1 1 0	1.248-02	3	3.00 011	5196.4215	-3	8 4 4	9 4 5	<b>2.25E-03</b>	4	200
5169.6461	-9	7 2 5	6 2 4	<b>1. 01E-04</b>	3	021H	5196.86305	4	7 2 6	6 2 5	<b>4.95E-02</b>	5	2.75 011
5170.5523	35	6 0 6	5 0 5	<b>9.65E-02</b>	8	2.66 011	5197.62510	-69	9 2 8	9 1 9	<b>1.40E-03</b>	10	4.23 011
5170.73770	4	4 3 1	4 2 2	<b>6.85E-03</b>	4	3.73 011	5198.33310	10	8 1 7	9 2 8	<b>7.50E-05</b>	15	200
5171.4171	74	1 0 2 8	1 0 2 9	<b>4.20E-04</b>	3	011	5198.82968	-4	8 1 7	7 2 6	<b>1.57E-03</b>	4	1.33 011
5171.75021	-11	9 2 7	1 0 2 8	2.736-03	10	3.38 200	5199.5714	5	8 3 6	8 1 7	<b>5.40E-04</b>	5	2.07 011
5172.05685	46	10 1 9	11 1 10	2.118-03	3	3.52 200	5199.6031	20	8 4 4	8 3 5	<b>1.67E-03</b>	10	4.44 011
5172.45250	9	2 2 0	1 1 1	<b>1.12E-02</b>	5	2.93 011	5199.67238	-15	7 3 5	7 1 6	<b>6.70E-04</b>	5	2.17 011
5172.79687	-8	6 1 6	5 0 5	9.756-03	4	1.74 011	● 5200.4592	386	6 5 2	5 5 1	8.15E-03	5	2.40 011
5172.88333	9	3 3 0	3 2 1	<b>4.91E-03</b>	4	3.64 011	5201.0990	-14	8 3 6	9 3 7	<b>4.14E-03</b>	10	3.34 200
5173.63352	5	1 1 0 1 1	1 2 0 1 2	1.7513-03	10	2.99 200	5201.48233	-17	9 0 9	8 1 8	<b>2.55E-03</b>	5	1.12 011
5173.6922	27	11 1 11	12 1 12	<b>1.88E-03</b>	10	3.21 200	5201.82037	-2	9 1 9	8 1 8	<b>3.81E-02</b>	3	2.85 011
● 5173.7629	234	9 6 3	1 0 6 4	<b>4.86E-04</b>	15	200	5201.9552	-12	1 0 3 8	1 0 2 9	<b>6.89E-04</b>	10	011
5173.84218	11	5 1 4	4 1 3	<b>9.52E-02</b>	3	2.67 011	5202.1737	-17	9 0 9	8 0 8	<b>3.80E-02</b>	4	2.84 011

Table 3. continued

observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength	ts	R	band	observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength	ts	R	band
5202.51158	-18	9 1 9	8 0 8	2.55E-03	5	1.11	011	5226.78932	4	9 1 8	8 1 7	2.28E-02	3	2.65	011
5202.77066	10	7 1 6	6 1 5	5.91E-02	3	2.79	011	5227.03446	-18	8 4 5	7 4 4	1. 01E-02	3	2.52	011
5203.03588	28	5 2 4	4 1 3	7.5033-03	5	2.47	011	5227.78833	11	8 4 4	7 4 3	1.00E-02	3	2.50	011
5203.49822	19	7 4 3	7 3 4	2.21E-03	3	4.00	011	5228.0551	41	7 2 6	8 2 7	1.08E-02	5	3.02	200
5203.99152	0	3 2 1	2 0 2	1.41E-03	3	2.96	011	5228.17933	3	8 3 5	7 3 4	1.93E-02	3	2.57	011
5204.11867	5	1 0 1	9 1 0	3.87E-04	5		011	5228.67028	-6	8 2 6	7 2 5	2. 92E-02	4	2.64	011
5204.30547	0	10 1	9 1 0	6.59E-04	4		011	5229.5575	45	3 3 0	3 1 3	7.00E-05	15		011
5204.56503	13	1 2 2	1 0 1	5.97E-05	4		011	5230.0044	-13	12 2 11	12 1 12	1.60E-04	10		011
5204.76247	8	4 0 4	5 2 3	6. 72E-04	3		200	5230.1381	-2	1 0 1	9 9 2 8	5.48E-04	4	0.99	011
5204.830	246	8 4 5	8 5 4	3.20E-05	15		200	5231.2815	16	12 0 1	2 1 1 0 1 1	7.20E-03	6	2.83	011
5205.25251	2	5 3 3	5 1 4	4. 74E-04	3		011	● 5231.771	760	8 5 4	7 5 3	8.30E-03	6	2.45	011
5205.69510	-14	8 1 7	9 1 8	6.85E-03	4	3.07	200	5233.26598	-2	6 2 4	7 2 5	1.52E-02	3	3.15	200
5207.64120	4	5 4 1	5 3 2	3.12E-03	6	3.84	011	5234.39056	-6	1 0 2	9 9 2 8	1.28E-02	4	2.71	011
5207.8516	43	5 1 5	5 3 2	9.31E-05	4		200	● 5234.906	-95	6 6 0	7 6 1	1.03E-03	10		200
5207.9601	-8	9 0 9	1 0 1 1 0	2.04E-04	10		200	5235.27913	10	4 3 2	3 2 1	9.48E-03	4	2.78	011
5208.1471	7	9 0 9	1 0 0 1 0	9.80E-03	4	4.51	200	5235.6994	18	1 0 5	5 1 0 4 6	2. 22E-04	7		011
5208.19498	-1	7 4 4	7 3 5	2. 20E-03	6	3.81	011	5235.96146	-7	9 3 7	8 3 6	1. 30E-02	4	2.67	011
5208.3654	20	9 1 9	1 0 1 1 0	1.03E-02	3	4.74	200	5236.19132	-24	4 3 1	4 1 4	1.22E-04	10		011
5208.47495	-9	4 4 0	4 3 1	2. 52E-03	6	3.92	011	● 5236.69661	42	8 6 3	7 6 2	2.37E-03	4	2.15	011
5208.6641	87	4 4 1	4 3 2	2.81E-03	15	4.34	011	5236.95778	2	6 3 3	7 3 4	1.03E-02	4	3.25	200
5209.36013	-6	4 3 2	4 1 3	2.9 SE-04	6		011	5237.18475	-4	4 3 1	3 2 2	9.30E-03	3	2.72	011
5209.95036	-23	7 3 4	6 3 3	2.90E-02	10	2.70	011	5238.06805	-3	6 4 2	7 4 3	4.98E-03	5	3.12	200
5209.9660	57	8 2 7	7 2 6	3.00E-02	5	2.37	011	5238.28774	4	6 4 3	7 4 4	5.02E-03	3	3.15	200
5210.0241	24	9 4 6	9 3 7	8.63E-04	5		011	5238.5254	-7	9 5 4	9 4 5	5.60E-03	10		011
5210.25968	15	8 2 7	9 2 8	6.65E-03	3	3.13	200	5239.50630	18	6 1 5	7 1 6	2. 05E-02	4	3.27	200
5210.43195	4	11 3	9 1 1 2 1 0	3.47E-04	4		011	5239.8237	-101	1 0 5	6 1 0 4 7	2.70E-04	10		011
5211.0315	11	7 1 6	8 2 7	9.24E-05	4		200	5239.8679	-63	1 3 1	1 2 1 3 1 1 3	4.60E-05	10		011
5211.20892	-4	7 4 4	6 4 3	1.33E-02	3	2.49	011	5239.8925	4	1 3 1	1 2 1 3 0 1 3	1.13E-04	10		011
5211.48936	-14	7 4 3	6 4 2	1.35E-02	4	2.53	011	5240.13467	11	6 3 4	7 3 5	1. 01E-02	4	3.12	200
5211.58350	14	6 2 5	5 1 4	4.95E-03	3	2.01	011	5240.2306	35	7 0 7	8 1 8	2.35E-04	10		200
5211.69865	17	7 2 5	6 2 4	4.42E-02	4	2.65	011	5240.3356	-4	13 1	13 12 1 12	3.70E-03	10	2.91	011
5211.8111	-34	10 0	10 9 1 9	1.18E-03	10	0.82	011	5240.3617	-46	13 0	13 12 0 12	3.90E-03	5	3.06	011
5211.9836	6	1 0 1	1 0 9 1 9	2.44E-02	5	2.96	011	5240.92172	10	7 0 7	8 0 8	1.83E-02	4	3.02	200
5212.1735	-74	10 0	10 9 0 9	2.49E-02	3	3.01	011	5241.20680	-10	8 5 4	8 4 5	7.45E-04	5		011
5212.2710	-4	10 4	7 1 0 3 8	5.85E-04	10		011	● 5241.4512	73	8 7 2	7 7 1	6.33E-04	4		011
5212.3459	-44	10 1	10 9 0 9	1.26E-03	4	0.88	011	5241.4723	35	5 2 3	4 1 4	2.63E-03	4	2.15	011
5212.41383	6	7 2 5	8 2 6	9.48E-03	3	3.24	200	5241.61851	50	7 1 7	8 1 8	1.90E-02	4	3.14	200
5213.0359	40	11 2	1 0 1 1 3 9	3.83E-04	4		200	5241.92712	17	7 5 3	7 4 4	1. 06E-03	5		011
● 5213.30158	-21	7 7 0	8 7 1	2.1 OE-04	6		200	5242.1517	-4	8 3 5	8 4 4	5.35E-05	15		200
5213.4529	-38	3 3 1	3 1 2	1.66E-04	7		011	5242.30933	-5	7 1 7	8 0 8	2.30E-04	4		200
5214.82892	-1	4 2 2	3 1 3	5.1 OB-03	6	2.44	011	5242.46080	31	6 5 1	6 4 2	1.18E-03	3	4.06	011
5215.03268	-4	7 3 4	8 3 5	6.4833-03	3	3.21	200	5242.53358	24	6 5 2	6 4 3	1.13E-03	5	3.86	011
● 5215.15355	34	7 6 2	8 6 3	9.40 E-04	10		200	5242.82819	-13	9 4 6	8 4 5	6.75E-03	3	2.57	011
5215.33957	14	8 1 7	7 1 6	3.83E-02	5	2.73	011	5243.3037	-77	11 1	1 0 1 0 2 9	3.05E-04	10	0.94	011
5215.5666	-51	5 4 1	5 5 0	2.37E-05	10		200	5244.64326	-24	9 2 7	8 2 6	1.84E-02	3	2.78	011
5215.68047	4	1 1 4	8 1 1 3 9	2.50E-04	10		011	5245.5211	29	5 3 2	5 1 5	1.52E-04	4		011
5216.0833	-101	7 5 3	6 5 2	1.00E-02	4	2.48	011	5245.90917	-5	6 1 5	6 3 4	3.16E-04	4		200
5216.8608	-52	7 5 2	8 5 3	2.04E-03	10	4.38	200	5245.95295	2	5 1 4	5 3 3	2.40E-04	3		200
5216.8853	-101	7 5 3	8 5 4	1.83E-03	10	3.93	200	5246.82922	-7	9 3 6	8 3 5	1. 20E-02	3	2.56	011
5217.5506	-2	1 0 0	1 0 1 0 2 9	1.56E-04	6		200	5247.0847	-68	5 3 2	5 4 1	6.1 OB-05	15		200
5217.72830	-14	7 4 3	8 4 4	3.60E-03	3	3.27	200	5247.5078	32	9 5 5	8 5 4	3.79E-03	15	3.21	011
5218.3190	-3	7 4 4	8 4 5	4.70E-03	10	4.28	200	5247.5986	-34	9 5 4	8 5 3	2.79E-03	10	2.36	011
5219.2303	-112	7 2 6	6 1 5	3.66E-03	6	1.93	011	5247.6977	-24	5 2 3	4 0 4	2.90 E-03	10	4.37	011
5219.3106	-31	11 2	10 11 0 11	1.66E-04	3		011	5247.8160	24	1 1 1	1 0 1 0 1 9	7.03E-03	5	2.67	011
5219.67117	7	12 3	1 0 1 2 2 1 1	1.56E-04	10		011	5248.65264	6	5 3 3	4 2 2	6.30E-03	6	2.50	011
5220.2314	51	12 4	9 12 3 10	1.00E-04	4		011	5249.1075	0	14 1	14 13 1 13	2.00E-03	6	3.36	011
5220.64558	5	3 3 1	2 2 0	1.26E-02	3	2.94	011	5249.1205	0	14 0	14 13 0 13	2.00E-03	6	3.36	011
5220.72930	-7	7 3 5	8 3 6	6. 68E-03	3	3.16	200	5249.2448	3	8 0 8	8 2 7	4.97E-04	5		200
5221.02177	6	3 3 0	2 2 1	1.29E-02	4	3.01	011	5249.43980	23	5 3 2	5 0 5	2.03E-04	3		011
● 5221.1911	-8	7 6 2	6 6 1	2.40E-03	4	2.43	011	5249.7469	-52	9 4 6	9 2 7	9.03E-05	15		011
5221.2297	-3	8 3 6	7 3 5	2.07E-02	5	2.70	011	5250.16359	2	1 0 3	8 9 3 7	7.45E-03	3	2.65	011
5221.6945	-48	11 0	1 1 1 0 1 1 0	5.90E-04	6	0.71	011	5251.272	-31	2 0 2	3 2 1	3.90E-03	10		200
5221.7818	13	1 1 1	1 1 1 0 1 1 0	1.32E-02	3	2.78	011	5251.7370	52	8 2 7	8 3 6	4.20E-05	15		200
5221.88170	-13	11 0	1 1 1 0 0 1 0	1.29E-02	4	2.71	011	● 5252.23308	323	9 6 4	8 6 3	2. 04E-03	3		011
5221.96845	-7	11 1	11 10 0 10	5.81E-04	2	0.70	011	5254.1522	-21	5 2 3	6 2 4	2.35E-02	4	3.32	200
5222.41487	3	7 1 6	8 1 7	1.26E-02	4	3.24	200	5254.34360	-16	5 3 2	4 2 3	6.20E-03	5	2.45	011
5222.4698	-44	9 2 8	8 2 7	2.23E-02	3	2.77	011	5255.2609	-16	1 2 1	1 1 1 1 2 1 0	1.05E-04	15		011
5222.7369	-46	10 1	9 1 0 3 8	1.13E-04	10		200	5255.3236	-36	6 0 6	7 1 7	2.14E-04	15		200
5223.88957	-3	4 2 2	3 0 3	2. 17E-03	3	3.12	011	● 5255.97412	63	5 5 0	6 5 1	3.37E-03	3	3.07	200
5224.40055	23	8 0 8	9 1 9	2. 25E-04	6		200	5256.6084	28	6 0 6	7 0 7	2.71E-02	3	3.01	200
5225.9905	-77	1 3 4	1 0 1 3 3 1 1	5.21E-05	10		011	5256.6425	2	1 2 2	1 1 1 1 2 1 0	3.70E-03	10	2.85	011
5226.4751	-4	8 2 7	7 1 6	1.83E-03	15	1.33	011	5256.84005	-44	9 7 3	8 7 2	5.40E-04	10		011

Table 3. continued

observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength %S	R	band	observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength %S	R	band
5257.11168	0	5 1 4	6 1 5	2.90E-02	3	3.13 200	5286.56403	15	5 4 1	4 3 2	6.518-03	3	2.89 011
5257.2703	43	8 4 5	8 2 6	9.97E-05	15	011	5286.81113	0	4 0 4	5 0 5	4.65E-02	2	2.98 200
5257.63202	0	5 4 2	6 4 3	5.88E-03	4	3.05 200	5287.0486	26	1 5 1 1 4	1 4 1 1 3	3.20E-05	5	011
5257.68056	-8	5 3 2	6 3 3	1.34E-02	3	3.11 200	● 5287.62713	-10	1 1 7 4	1 0 7 3	2.45E-04	9	011
5257.76843	9	6 1 6	7 1 7	2.67E-02	3	2.99 200	5288.3415	-14	8 1 7	8 2 6	4.40E-05	10	200
5257.91120	3	12 1 11	11 1 10	3.75E-03	3	2.84 011	5288.40267	55	5 3 2	4 1 3	8.47E-04	3	3.41 011
5258.25210	-1	6 3 3	6 1 6	1.17E-04	4	011	5288.6247	7	5 1 5	5 2 4	1.21E-04	10	200
5258.4863	-73	1 0 4	7 9 4 6	4.02E-03	10	2.60 011	5289.2825	-5	4 1 4	5 1 5	4.4113-02	3	2.93 200
5258.5648	-7	10 2 9	1 0 2 8	1.70E-04	4	200	5289.8874	27	1 0 3 8	9 2 7	3.07E-04	10	011
5259.17919	26	5 3 3	6 3 4	1.32E-02	3	3.02 200	5290.88847	31	6 4 2	6 2 5	6.41E-05	6	011
5259.34821	4	1 0 2 8	9 2 7	9.47E-03	3	2.64 011	● 5291.3983	-3	11 8 3	1 0 8 2	6.43E-05	10	011
5260.29482	0	6 3 4	5 2 3	4.30E-03	4	2.48 011	5291.9530	16	4 3 2	3 1 3	2.77E-04	5	011
● 5260.8732	-30	9 8 1	8 8 0	1.22E-04	10	011	5293.3299	19	3 1 2	4 1 3	4.37E-02	2	3.02 200
5261.0966	8	7 2 6	7 3 5	5.24E-05	10	200	5294.65536	6	3 2 1	4 2 2	2.913? -02	3	3.01 200
● 5261.97718	0	1 0 4 6	9 4 5	3.94E-03	2	1.29 011	5294.7386	-6	7 3 4	6 2 5	1.88E-03	10	1.88 011
5263.01002	-4	7 0 7	7 2 6	8.49E-04	4	200	5295.67510	0	3 3 0	4 3 1	1.18E-02	3	2.99 200
5263.31730	-69	5 2 4	6 2 5	2.57E-02	3	3.34 200	5295.8414	7	3 3 1	4 3 2	1.18E-02	5	2.99 200
5264.9768	60	7 4 4	7 2 5	1.12E-04	10	011	5296.3528	-84	1 2 5 7	1 1 5 6	4.64E-04	5	011
5265.36545	-16	10 3 7	9 3 6	6.79E-03	3	2.60 011	5296.53195	0	3 0 3	3 2 2	8.43E-04	5	3.25 200
5267.08041	11	1 3 2 1 2	1 2 2 1 1	1.68E-03	3	2.74 011	5297.2622	-25	6 0 6	6 1 5	7.50E-05	6	200
5268.5883	-28	1 3 2 1 2	1 2 1 1 1	4.13E-05	15	011	5297.91873	-9	3 2 2	4 2 3	2.89E-02	2	2.91 200
5268.6597	37	6 2 5	6 3 4	8.20E-05	10	200	5298.5228	83	12 4 9	1 2 4 8	3.61E-05	15	200
5269.4991	-21	1 0 1	2 2 0	2.35E-04	10	200	5298.88897	19	1 2 4 8	1 1 4 7	9.75E-04	4	011
5269.5548	42	5 0 5	6 1 6	1.27E-04	15	200	5299.03654	-8	1 2 6 7	1 1 6 6	1.9133-04	10	011
5269.7380	-36	13 6 8	13 5 9	9.40E-05	15	011	5299.41062	-16	2 0 2	2 2 1	2.90E-04	8	200
5270.04147	28	7 3 5	6 2 4	2.35E-03	6	2.08 011	5300.1132	12	1 2 3 9	1 1 3 8	1.47E-03	4	011
5271.09921	-6	4 4 1	3 3 0	9.20E-03	4	3.01 011	5300.2683	13	8 2 7	8 2 6	9.03E-04	10	3.12...200
5271.12890	8	4 4 0	3 3 1	9.50E-03	6	3.11 011	5300.5850	-24	9 5 4	1 0 2 9	1.15E-04	15	011
5271.85524	-7	5 0 5	6 0 6	3.71E-02	3	2.99 200	5301.25263	6	6 4 3	5 3 2	4.07E-03	3	2.68 011
5272.1137	15	6 4 3	6 2 4	1.20E-04	10	011	5301.4104	-1	1 0 3 8	1 0 3 7	2.40E-04	10	200
5272.15537	-3	6 2 4	5 1 5	1.31E-03	3	2.08 011	5301.76475	4	3 0 3	4 0 4	5.32E-02	2	2.98 200
● 5272.23427	-18	1 0 7 4	9 7 3	3.87E-04	10	011	● 5302.9906	407	1 2 7 6	1 1 7 5	1.02E-04	10	011
5272.59413	0	11 2 9	1 0 2 8	4.59E-03	6	2.57 011	5303.40568	9	13 4 10	12 4 9	5.00E-04	10	011
5273.1664	-35	10 6 4	10 5 5	3.33E-04	4	011	5304.7011	33	3 1 3	4 1 4	5.30E-02	10	3.21 200
5273.23135	7	6 3 3	5 2 4	3.84E-03	2	2.27 011	5305.15063	-11	1 4 2 1 2	1 3 2 1 1	4.55E-04	6	011
*5273.4372	-13	17 0 17	16 0 16	3.50E-04	10	011	5305.6941	10	3 1 3	3 2 2	1.1 OB-04	4	200
5273.64546	0	5 1 5	6 1 6	3.63E-02	3	2.99 200	● 5306.3488	249	10 7 3	1 0 6 4	7.61E-05	6	011
5273.92555	-41	11 4 8	10 4 7	2.13E-03	9	011	5306.63138	-41	7 2 5	6 1 6	6.27E-04	4	2.13 011
5274.4480	-14	9 6 4	9 5 5	2.14E-04	15	011	● 5308.59150	6	7 7 0	7 6 1	1.40E-04	10	011
5274.5277	5	5 2 4	5 3 3	9.81E-05	10	200	5308.8166	-94	12 6 7	1 2 6 6	1.28E-05	15	200
5274.75674	10	4 2 2	5 2 3	2.76E-02	4	3.04 200	5308.9327	-2	7 2 5	6 0 6	8.30E-04	6	3.24 011
5274.89366	-38	6 0 6	6 2 5	1.18E-03	5	3.38 200	5308.9930	23	1 2 6 6	1 2 6 7	4.11E-05	15	200
5275.1310	14	4 1 3	5 1 4	3.88E-02	5	3.15 200	5309.1298	56	4 2 3	5 1 4	3.80E-05	10	200
5275.2627	-28	8 6 2	8 5 3	1.82E-04	15	011	5309.8752	42	6 1 5	6 . 2 4	1.118-04	4	200
5275.94622	-17	5 1 5	6 0 6	1.63E-04	5	200	5311.46160	7	2 1 1	3 1 2	4.25E-02	2	2.96 200
● 5275.9715	345	7 6 1	7 5 2	7.00E-04	3	011	5312.2845	-33	1 1 4 8	1 1 4 7	1.20E-04	15	200
5276.07417	1	6 2 4	5 0 5	1.47E-03	4	3.20 011	5313.45297	3	2 2 0	3 2 1	2.14E-02	2	2.90 200
5276.11246	0	4 3 1	3 1 2	4.70E-04	6	011	5314.1062	-28	5 3 3	4 1 4	3.70E-04	10	011
*5276.1465	64	1 0 8 3	9 8 2	1.07E-04	6	011	5314.6606	33	13 6 8	12 6 7	1.31E-04	15	011
5276.3101	149	4 4 0	5 4 1	5.1 OE-03	4	3.10 200	5314.81586	-1	2 2 1	3 2 2	2.17E-02	3	2.92 200
5276.3224	-73	4 4 1	5 4 2	5.1 OE-03	4	3.10 200	5314.8995	0	13 6 7	1 2 6 6	4.70E-05	15	011
5276.4527	-4	7 3 4	7 0 7	1.1 OB-04	10	011	5315.43615	6	7 4 4	6 3 3	2.33E-03	5	2.45 011
*5276.5171	-108	6 6 1	6 5 2	5.95E-04	6	011	5315.54800	0	13 3 10	12 3 9	6.07E-04	5	011
5276.6988	22	12 3 10	11 3 9	1.94E-03	5	011	5315.62408	8	5 1 4	5 2 3	1.61E-04	10	200
5277.12362	-9	1 4 2 1 3	1 3 2 1 2	7.48E-04	5	011	5317.0070	22	2 0 2	3 0 3	6.00E-02	10	3.33 200
5277.20364	3	4 3 1	5 3 2	1.47E-02	4	3.00 200	5317.72368	-8	9 3 7	9 3 6	6.60E-04	6	200
5277.5505	-36	1 4 1 1 3	1 3 1 1 2	8.00E-04	10	011	5317.8150	-28	13 4 9	12 4 8	4.286-04	10	011
5277.7819	20	4 3 2	5 3 3	1.46E-02	3	2.97 200	5317.87745	-28	7 2 6	7 2 5	2.05E-03	10	3.18 200
5278.01095	1	8 3 6	7 2 5	1.33E-03	3	1.90 011	5318.5311	15	4 1 3	4 2 2	1.69E-04	3	200
5278.03609	-5	5 4 2	5 2 3	5.08E-05	10	011	5318.6542	42	2 1 1	2 2 0	1.1913-04	15	200
5279.519	-77	7 0 7	7 1 6	6.89E-05	15	200	5319.2486	6	3 1 2	3 2 1	1.65E-04	10	200
5279.79193	8	1 1 5	6 1 0 5 5	9.75E-04	4	011	5319.89607	-1	2 1 2	3 1 3	4.52E-02	2	2.91 200
5280.7290	7	4 2 3	5 2 4	2.84E-02	4	2.99 200	● 5320.14670	-3	10 7 4	10 7 3	2.27E-04	6	200
5280.9068	-73	7 1 7	7 1 6	1.04E-03	10	3.25 200	5320.33240	-7	5 3 3	4 0 4	1.54E-04	10	011
● 5280.9068	0	1 8 0 1 8	1 7 0 1 7	1.04E-04	15	011	● 5320.94119	-86	5 5 0	4 4 1	9.85E-03	6	3.10 011
5282.8920	-37	4 0 4	5 1 5	5.23E-05	10	200	● 5321.7517	0	9 9 1	9 9 0	8.68E-05	5	200
5283.2602	-46	1 1 3 8	1 0 3 7	3.52E-03	5	011	5322.2055	27	1 4 3 1 1	1 3 3 1 0	4.43E-05	10	011
5283.2920	57	5 2 3	5 3 2	4.86E-05	10	200	5322.74203	0	10 6 5	10 6 4	2.22E-04	5	200
5283.4080	-4	11 6 6	1 0 6 5	3.79E-04	15	011	5322.75984	5	1 0 6 4	1 0 6 5	1.94E-04	6	200
5284.41086	30	1 2 2 1 0	1 1 2 9	2.15E-03	7	011	5324.92726	-9	10 5 6	10 5 5	2.95E-04	6	200
5284.5335	-5	5 0 5	5 2 4	1.20E-03	5	2.87 200	5325.46019	25	10 5 5	10 5 6	3.80E-04	4	200
5286.35348	1	5 4 2	4 3 1	6.3 8E-03	4	2.85 011	● 5326.2381	5	9 7 2	9 7 3	4.70E-04	10	200

Table 3. continued

observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength	ts	R	band	observed posit ion	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength	ts	R	band
5328.39658	4	8 4 5	7 3 4	1.24E-03	6	2.2a	011	5378.08933	-a	7 4 3	a 5 4	1.50E-04	10		120
● 5328.7823	107	9 6 4	9 6 3	9.18E-04	4		200	537a.5285	5	2 0 2	1 1 1	1.58E-04	10		200
5329.32280	11	1 1 0	2 1 1	2.96E-02	3	2.86	200	5378.76858	13	1 0 1	0 0 0	2.65E-02	3	2.76	200
● 5329.3960	-25	8 8 1	8 8 0	5.30E-04	10		200	5379.1876	19	2 2 0	3 0 3	1.00E-04	4		200
5330.67136	1	8 3 6	8 3 5	1.77E-03	4	3.26	200	5379.465a	-9	8 0 8	9 1 9	1.42E-04	7		120
5331.1234	0	9 5 5	9 5 4	7.41E-04	3		200	5379.7230	-62	6 2 4	5 3 3	9.00E-05	15		200
5331.30666	16	9 5 4	9 5 5	7.22E-04	3		200	5379.99a62	-37	1 1 0	1 0 1	1.04E-04	10		200
95331.72433	-6	8 7 2	8 7 1	1.11E-03	7		200	5380.64662	-5	9 5 5	a 4 4	5.17E-04	6		011
5332.595	-34	1 0 1	2 0 2	5.47E-02	4	3.62	200	5381.1845	16	7 1 6	a 2 7	5.00E-05	6		120
5332.6250	11	6 2 5	6 2 4	2.55E-03	10	1.85	200	5381.2583	-4	8 1 8	9 1 9	1.43E-04	4		120
*5334.2093	1	8 6 3	8 6 2	2.04E-03	10		200	5381.5977	-25	9 5 4	a 4 5	5.52E-04	4		011
5334.4935	-9	8 4 4	7 3 5	1.30E-03	10	2.16	011	5381.6214	26	8 1 8	9 0 9	1.31E-04	10		120
5334.83310	1	1 1 1	2 1 2	3.06E-02	3	2.85	200	5381.66065	-12	1 0 3	7 9 2	1.27E-04	5		011
5335.19075	-6	9 4 5	9 4 6	8.45E-04	3		200	5381.7499	15	2 1 1	2 0 2	1.25E-04	4		200
5335.45936	-26	3 0 3	3 1 2	2.17E-04	4		200	5381.91095	-15	7 4 3	6 2 4	2.95E-04	5		011
5336.6464	14	8 5 3	8 5 4	1.44E-03	6		200	53a2.02596	-7	6 4 3	5 2 4	2.51E-04	4		011
● 5339.0287	15	7 6 2	7 6 1	4.28E-03	10		200	5382.1198	-3	8 1 7	9 1 8	1.11E-04	4		120
5339.59622	15	9 4 6	8 3 5	6.80E-04	10	2.37	011	53a3.5332	-59	a 2 6	8 2 7	8.65E-04	3	2.39	200
5340.3675	-23	7 3 5	7 3 4	3.52E-03	4	2.84	200	5383.984a	-5	4 1 3	4 1 4	5.40E-03	7	2.59	200
5341.4059	80	7 5 3	7 5 2	3.38E-03	10	2.84	200	5384.52510	4	9 2 7	8 1 8	1.02E-04	4		011
5341.416-1	-13	7 5 2	7 5 3	3.56E-03	10	2.99	200	● 53a4. a145a	-50	7 6 1	6 5 2	2.33E-03	3	2.92	011
● 5343.2440	-48	6 6 1	6 6 0	1.04E-02	4		200	5385.1785	-23	a 2 6	9 2 7	8.10E-05	10		120
5343.2729	80	7 4 4	7 4 3	3.08E-03	7	2.14	200	5385.21639	-4	9 2 7	8 0 8	2.14E-04	8		011
5343.79788	17	7 4 3	7 4 4	3.90E-03	5	2.70	200	5390.47858	17	2 1 2	1 1 1	3.35E-02	4	2.6a	200
5344.1988	8	5 2 4	5 2 3	8.20E-03	6	2.90	200	5391.2755	70	a 4 4	7 2 5	3.30E-04	6		011
*5345.5942	101	6 5 2	6 5 1	1.45E-02	10	3.09	200	5391.5855	65	7 2 5	7 1 6	2.53E-05	10		200
5346.2719	-18	1 0 1	1 1 0	1.44E-04	15		200	5392.3548	53	3 2 1	4 3 2	2.65E-05	10		120
5346.7599	-57	6 5 2	6 3 3	1.751.4-04	5		011	5392.5681	31	7 1 6	8 1 7	1.81E-04	15		120
5347.37556	-10	6 3 4	6 3 3	7.21E-03	3	2.80	200	5392.82888	7	2 0 2	1 0 1	4.70E-02	4	2.64	200
5347.64117	10	6 4 3	6 4 2	8.01E-03	4	2.79	200	5394.9727	-2a	a 3 6	7 0 7	1.10E-04	7		011
5347.78759	17	6 4 2	6 4 3	7.95E-03	4	2.76	200	5395.42652	3	2 1 1	1 1 0	3.32E-02	5	2.70	200
5348.31625	0	0 0 0	1 0 1	2.47E-02	3	2.79	200	5395.7684	47	4 2 2	4 1 3	8.13E-05	10		200
● 5349.17263	12	5 5 1	5 5 0	2.35E-02	4	2.68	200	5397.6730	26	5 1 4	5 0 5	7.10E-05	10		200
5350.7392	11	10 1 10	11 0 11	5.15E-05	10		120	5397.9a90	105	7 2 5	6 3 4	9.30E-05	10		200
5351.3586	-34	7 5 2	6 4 3	1.90E-03	5	2.74	011	● 539a.0235	-4a3	6 6 0	7 5 3	6.81E-05	15		200
53 s1.40500	-27	6 3 3	6 3 4	7.26E-03	6	2.79	200	5399.0295	4	a 2 7	9 2 a	1.13E-04	4		120
5351.6923	-22	4 0 4	3 2 1	1.87E-04	5		200	5399.15649	5	7 2 5	a 2 6	1.56E-04	3		120
5351.8140	8	3 1 3	2 2 0	3.75E-05	15		200	● 5399. a145	395	a 6 3	7 5 2	1.38E-03	6		011
5351.9250	-2	9 3 6	9 3 7	4.54E-04	15		200	5400.0300	-10	3 2 1	3 1 2	1.31E-04	15		200
5352.3589	19	9 4 5	8 3 6	5.68E-04	10	1.71	011	5400.22411	-5	7 4 4	6 2 5	2.40E-04	5		011
5352.52988	55	4 2 3	4 2 2	1.68E-02	3	3.06	200	5400.89077	37	9 4 5	a 2 6	2.45E-04	3		011
5353.67852	15	5 3 2	5 3 3	1.37E-02	4	2.74	200	5402.377a	13	10 3 7	9 4 6	1.17E-05	15		200
5354.1026	13	2 1 2	2 1 1	1.66E-02	4	2.87	200	5402.5760	-93	5 1 4	4 2 3	2.80E-04	6		200
● 5354.2369	-145	4 4 0	4 4 1	5.33E-02	3	2.73	200	5402.95611	0	3 1 3	2 1 2	5.12E-02	4	2.65	200
5355.7694	-70	4 3 2	4 3 1	2.82E-02	7	3.10	200	5404.7787	-7	2 1 2	1 0 1	3.55E-04	7		200
5356.12635	2	4 3 1	4 3 2	2.6133-02	4	2.87	200	5404.80810	1	6 1 5	6 1 6	1.80E-03	5	2.34	200
5356.3337	-25	5 0 5	4 2 2	1.74E-04	10		200	5405.74804	20	3 0 3	2 0 2	5.97E-02	3	2.62	200
5356.80499	-39	4 2 2	5 0 5	2.326-04	4		200	5406.0344	-8	3 2 2	2 2 1	2.51E-02	4	2.64	200
5357.89602	1	3 2 2	3 2 1	2.86E-02	3	2.81	200	5406.2442	40	6 0 6	7 1 7	2.15E-04	6		120
5358.27735	-2	3 3 1	3 3 0	4.4643-02	2	2.77	200	5407.22231	-4	3 2 1	2 2 0	2.48E-02	4	2.61	200
5358.32879	-9	3 3 0	3 3 1	4.46E-02	3	2.75	200	5408.36620	-13	4 0 4	3 1 3	7.36E-04	4		200
5358.85600	-67	8 3 6	7 4 3	4.41E-05	15		200	5410.12883	9	3 1 2	2 1 1	4.88E-02	2	2.61	200
5360.0614	-20	9 3 6	8 1 7	5.4814-04	3		011	5410.8892	-6	6 1 6	7 1 7	3.5114-04	10		120
5360.2152	17	5 4 1	4 2 2	1.79E-04	5		011	5411.96865	-11	1 0 4	6 9 2	1.80E-04	3		011
5360.46360	-1	1 1 1	1 1 0	3.42E-02	2	2.80	200	5412.0784	42	2 2 1	2 1 2	2.54E-05	15		200
5360.93570	-9	2 2 1	2 2 0	5.22E-02	2	2.79	200	5412.6166	-11	1 1 5	6 1 0	1.10E-04	4		011
5361.10245	2	3 2 . 1	3 2 2	2.82 E-02	2	2.75	200	5414.6714	34	9 6 4	a 5 3	3.318-04	10		011
5361.70958	1	4 2 2	4 2 3	1.47E-02	4	2.61	200	5414.75650	0	4 1 4	3 1 3	5.8344-02	4	2.62	200
5362.6106	-20	1 1 3 8	1 1 3 9	9.23E-05	10		200	5414.90970	-19	3 1 3	2 0 2	5.70E-04	10		200
5364.0649	1	5 2 3	5 2 4	8.09E-03	10	2.71	200	5416.53220	-11	7 1 6	7 1 7	1.08E-03	4	2.35	200
5365.69860	-3	1 1 0	1 1 1	3.47E-02	6	2.7a	200	5416.92901	4	7 7 1	6 6 0	1.27E-03	3		011
5366.1596	-37	8 5 4	7 4 3	1.06E-03	4	2.65	011	5417.1375	45	5 1 4	6 1 5	4.45E-04	10		120
5366.2821	49	9 1 9	10 0 10	1.0912-04	10		120	5417.42702	3	4 0 4	3 0 3	6.36E-02	2	2.62	200
5366.3350	-19	3 2 1	4 0 4	2.4513-04	10		200	5418.4239	2	4 3 2	3 3 1	1.43E-02	4	2.62	200
5366.47185	-9	8 5 3	7 4 4	1.05 E-03	4	2.55	011	5418.5623	-7	4 3 1	3 3 0	1.41E-02	3	2.5a	200
5367.9855	56	9 1 8	1 0 2 9	6.26E-05	10		120	5418.9764	-6	4 2 3	3 2 2	3.57E-02	3	2.62	200
● 5369.71564	-37	6 6 1	5 5 0	4.03E-03	4	3.20	011	5419.7868	-46	6 1 5	5 2 4	3.68E-04	3		200
5369.79586	-11	2 1 1	2 1 2	1.63E-02	4	2.71	200	5419.93112	-12	a 4 5	7 2 6	1.98E-04	10		011
5371.7690	11	6 4 2	5 2 3	2.58E-04	6		011	5420.69266	-12	5 0 5	6 0 6	5.39E-04	3		120
5372.24568	48	1 0 4 6	9 3 7	2.68E-04	10		011	5421.68677	0	4 2 2	3 2 1	3.45E-02	2	2.55	200
5375.0750	-14	7 2 5	7 2 6	1.88E-03	10	2.50	200	5421.7878	-5	5 0 5	4 1 4	1.00E-03	6		200
5375.92228	-7	3 1 2	3 1 3	9.70E-03	7	2.80	200	5423.6306	12	3 2 2	3 0 3	a.85E-04	10	2.44	200

Table 3. continued

observed position	o-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength %	R	band	observed position	o-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength %	R	band		
5423.90572	-3	4 1 3	3 1 2	5.3213-02	3	2.60	200	5462.12835	14	2 1 1	3 1 2	7.30E-04	6	120	
5424.20920	-2	4 2 3	4 0 4	1.23E-03	3	2.22	200	● 5462.19320	-11	8 8 1	7 7 0	2.89E-04	3	011	
5425.0655	-65	9 3 7	8 0 8	8.30E-05	10		011	5462.4381	-27	6 3 4	7 3 5	1.14E-04	10	120	
5425.57242	1	5 1 5	6 1 6	5.2 8E-04	4		120	5462.92953	-1	8 2 7	7 2 6	1.67E-02	5	2.50	200
5425.87868	-25	5 1 5	4 1 4	5.7013-02	3	2.63	200	5463.8694	-48	9 0 9	8 1 8	1.27E-03	15	200	
5428.01388	4	5 0 5	4 0 4	5.87E-02	2	2.57	200	5464.2747	-20	9 1 9	8 1 8	1.80E-02	4	2.54	200
5428.22316	-4	8 1 7	8 1 8	5.33E-04	5	1.98	200	5464.4476	52	8 4 4	7 4 3	5.07E-03	6	200	
5429.1994	57-I	5 4 2	4 4 1	1.25E-02	6	2.53	200	5464.56125	0	9 0 9	8 0 8	1.78E-02	4	2.50	200
5429.3530	0	1 0 6	5 9 5	1.92E-04	6		011	5465.21008	7	5 2 4	4 1 3	5.29E-04	4	200	
5429.4729	400	1 0 6	4 9 5	1.76E-04	10		011	5465.56203	-1	8 3 6	7 3 5	9.70E-03	5	2.39	200
5429.7766	-87	4 3 1	4 2 2	1.87E-04	10		200	5466.00550	9	3 2 1	4 2 2	5.1 0E-04	3	120	
5431.1517	5	5 2 4	4 2 3	3.62E-02	2	2.56	200	5467.51281	9	8 1 7	7 1 6	2.03E-02	6	2.72	200
5431.2058	-43	5 3 3	4 3 2	1.88E-02	3	2.54	200	● 5468.2173	-9	9 6 3	8 6 2	1.07E-03	7	200	
5431.66672	-5	5 3 2	4 3 1	1.87E-02	3	2.53	200	5468.4640	-6	4 3 2	4 1 3	1.62E-04	10	200	
● 5431.85315	-90	8 7 2	7 6 1	7.16E-04	3		011	5468.9381	21	2 1 2	3 1 3	8.03E-04	3	120	
5432.10544	52	5 1 5	4 0 4	1.27E-03	4		200	5469.21725	6	3 2 2	4 2 3	5.24E-04	3	120	
5433.69538	-8	4 0 4	5 0 5	6.88E-04	4		120	5469.5829	-1	8 3 5	7 3 4	9.95E-03	4	2.52	200
5433.90483	8	6 0 6	5 1 5	1.26E-03	5		200	5470.31830	-2	3 2 1	2 0 2	5.34E-04	3	2.11	200
5435.86525	-4	5 2 3	4 2 2	3.57E-02	2	2.57	200	5471.47752	-7	9 5 5	8 5 4	1.47E-03	4	200	
5436.1024	1	7 1 6	6 2 5	3.68E-04	4		200	5471.52938	-4	9 5 4	8 5 3	1.46E-03	3	200	
5436.34911	-2	6 1 6	5 1 5	4. 83E-02	2	2.57	200	5471.97784	14	9 2 8	8 2 7	1.03E-02	3	2.42	200
5436.63526	-3	5 1 4	4 1 3	4.80E-02	3	2.52	200	5472.33524	-25	10 0 10	9 1 9	6.88E-04	4	200	
5437.8238	29	6 0 6	5 0 5	4.88E-02	4	2.52	200	5472.54781	-2	10 1 10	9 1 9	1.07E-02	3	2.44	200
*5438. 79261	37	6 5 2	5 5 1	4.40E-03	5	2.46	200	5472.6977	-59	10 0 10	9 0 9	1.15E-02	15	2.62	200
5439.2897	-9	9 1 8	9 1 9	3.04E-04	15		200	5472.91067	4	10 1 10	9 0 9	6.42E-04	5	200	
5439.86290	48	5 2 4	6 2 5	3.90E-04	4		120	5473.35680	-3	8 2 6	7 2 5	1.42E-02	4	2.42	200
5439.98150	1	4 1 4	5 1 5	7.07E-04	3		120	5475.5175	-19	9 1 8	8 1 7	1.45E-02	10	3.17	200
5440.2677	-19	6 1 6	5 0 5	1.26E-03	4		200	● 5476.91537	-2	9 8 2	8 7 1	1.53E-04	10	011	
5441.4195	21	6 4 2	5 4 1	7.70E-03	6	2.45	200	5477.1822	2	5 3 3	6 3 4	1.75E-04	10	120	
5442.53727	-10	6 2 5	5 2 4	3.08E-02	4	2.48	200	● 5477.7675	198	10 6 5	9 6 4	6.83E-04	3	200	
5443.37330	-9	6 3 4	5 3 3	1.76E-02	3	2.47	200	5477.9981	-45	2 1 2	3 0 3	8.95E-05	5	120	
5443.76910	-10	1 1 6	1 0 5	7.30E-05	10		011	5478.3608	23	4 2 2	3 1 3	3.00E-04	10	200	
5444.0964	12	1 1 6	1 0 5	6.95E-05	6		011	5479.43912	-13	8 2 7	7 1 6	4.55E-04	4	200	
5444.50991	6	6 3 3	5 3 2	1.76E-02	3	2.48	200	5480.2314	8	11 0 11	10 1 10	3.40E-04	10	200	
5444.82160	-14	7 0 7	6 1 6	1.20E-03	10		200	5480.3180	-11	10 2 9	9 2 8	6.52E-03	4	2.60	200
5446.2095	0	7 1 7	6 1 6	3.70E-02	3	2.50	200	5480.3374	-11	11 1 11	10 1 10	6.26E-03	5	2.48	200
● 5446.6798	681	9 7 3	8 6 2	5.84E-04	15		011	5480.41812	-5	11 0 11	10 0 10	6.31E-03	6	2.50	200
5446.94781	-12	3 0 3	4 0 4	8.70E-04	4		120	5480.5244	4	11 1 11	10 0 10	3.24E-04	3	200	
5447.12275	8	7 0 7	6 0 6	3. 81E-02	3	2.55	200	5481.23156	6	10 5 6	9 5 5	8.90E-04	3	200	
● 5447.36603	-5	7 6 2	6 6 1	1.31E-03	4		200	5481.36784	7	10 5 5	9 5 4	9.83E-04	3	200	
5447.4957	-35	9 2 8	9 0 9	3.33E-04	6		200	5481.4972	-3	9 3 6	8 3 5	5.90E-03	3	200	
5448.18743	-14	6 1 5	5 1 4	3.84E-02	2	2.50	200	5482.0597	18	3 3 1	2 2 0	3.40E-04	10	200	
5448.4320	-14	7 3 5	7 1 6	3.30E-04	10		200	5402.4264	4	3 3 0	2 2 1	3.58E-04	10	200	
5448.58233	36	4 2 2	5 2 3	7.1 0E-04	4		120	5482.79545	-20	10 1 9	9 1 8	6.22E-03	4	2.38	200
5448.77628	7	3 2 2	2 1 1	3.37E-04	3		200	5482.8628	0	4 1 4	4 1 3	9.79E-05	10	120	
● 5450.2543	217	7 5 3	6 5 2	5.1 0E-03	4	2.39	200	5483.00756	1	2 2 0	3 2 1	4.00E-04	4	120	
5451.00298	-3	8 1 7	7 2 6	4.00E-04	4		200	5483.3611	-5	9 2 8	8 1 7	3.50E-04	6	200	
5451.7650	26	2 0 2	3 1 3	9.70E-05	4		120	5483.3861	-23	1 1 1	2 1 2	5.50E-04	5	120	
5452.6394	3	1 0 2	8 9 3	6.16E-05	3		200	5483.5128	60	9 2 7	8 2 6	8.90E-03	4	2.55	200
5452.8281	-28	9 4 6	8 1 7	8.1 0E-05	5		011	5484.2220	-45	10 4 7	9 4 6	2.03E-03	4	200	
5452.8281	35	6 1 6	6 1 5	8.1 0E-05	5		120	5484.36085	-15	2 2 1	3 2 2	3.94E-04	3	120	
5452.99143	-1	7 4 4	6 4 3	6.9114-03	2	2.44	200	5484.61128	-9	10 3 8	9 3 7	3.48E-03	3	200	
5453.1251	-59	7 2 6	6 2 5	2.60E-02	10	2.71	200	5485.08433	0	11 1 10	10 2 9	1.75E-04	5	200	
5454.46410	16	3 1 3	4 1 4	7.85E-04	4		120	5486.73302	-12	11 6 6	10 6 5	2.06E-04	6	200	
5454.4851	-36	1 0 2	9 10 0	1.60E-04	10		200	5486.74829	-17	11 6 5	10 6 4	1.88E-04	4	200	
5454.53244	30	6 3 4	6 1 5	3.07E-04	6		200	5487.42110	-14	4 2 2	3 0 3	7.45E-04	3	2.02	200
5454.74557	-12	8 0 8	7 1 7	1.03E-03	6		200	5487.6061	22	12 0 12	11 1 11	3.44E-04	10	200	
5454.8355	26	7 3 5	6 3 4	2.11E-02	5	3.68	200	5487.6621	-17	12 1 12	11 1 11	3.56E-03	4	2.64	200
5455.0089	-54	2 2 0	1 0 1	1.soil-04	10		200	5487.7006	-23	12 0 12	11 0 11	3.45E-03	6	2.56	200
5455.0292	3	8 7 2	7 7 1	3.36E-04	3		200	5487.7574	18	12 1 12	11 0 11	2.90E-04	10	200	
5455.50500	-5	8 1 8	7 1 7	2.66E-02	2	2.49	200	5488.4190	-48	9 5 5	8 3 6	1.19E-04	10	011	
5456.02974	-11	8 0 8	7 0 7	2.67E-02	2	2.48	200	5490.23152	0	12 7 6	11 6 5	2.09E-04	10	011	
5456.78927	6	8 1 8	7 0 7	1.02E-03	4		200	5490.2666	0	12 7 5	11 6 6	2.1 0E-04	10	011	
5457.16456	5	7 3 4	6 3 3	1.40E-02	2	2.46	200	5490.39147	-17	11 5 7	10 5 6	4.57E-04	4	200	
5457.90420	7	4 2 3	3 1 2	4.72E-04	2		200	5490.6147	23	11 4 8	10 2 9	1.83E-04	10	011	
● 5458.08502	-17	8 6 3	7 6 2	1.39E-03	4		200	5490.70548	-12	11 5 6	10 5 5	4.59E-04	6	200	
5458.47053	-27	7 1 6	6 1 5	2.76E-02	3	2.46	200	● 5491.52083	29	10 8 3	9 7 2	6.47E-05	10	011	
● 5461.1646	457	8 5 4	7 5 3	4.22E-03	4		200	5491.60737	-4	4 3 1	5 3 2	1.98E-04	3	120	
● 5461.3678	62	1 0 7	4 9 6	1.74E-04	3		011	5492.3624	-53	10 2 8	9 2 7	3. 01E-03	15	200	
5461.4573	2	5 3 3	5 1 4	2.65E-04	6		200	5492.5619	-67	10 3 7	9 3 6	3.21E-03	5	200	
● 5461.9097	-30	9 8 2	8 8 1	2.25E-03	10		200	5493.2596	24	11 4 8	10 4 7	9.50E-04	10	200	
5461.95350	-1	7 2 5	6 2 4	2.40E-02	3	2.71	200	5494.5228	0	13 1 13	12 1 12	1.73E-03	5	200	



Table 3. continued

observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength %	R	band	observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength %	R	band
5494.5715	0	13 0 13	12 0 12	1.20E-04	6	200	5538.3378	0	8 3 5	8 1 8	2.09E-05	15	200
5495.07383	-10	12 2 11	11 2 10	1.57E-03	3	200	5539.52022	0	2 1 2	1 1 1	6.55 E-04	3	120
5495.1408	23	1 2 6 7	1 1 6 6	9.09E-05	10	200	5540.1217	9	4 1 3	4 1 4	8.43E-05	10	120
5495.2311	-2-1	4 3 1	4 1 4	8.44E-05	10	200	5540.9538	-58	1 2 5 8	1 1 3 9	2.74E-05	10	011
5495.3401	-1	1 1 1	2 0 2	4.26E-05	10	120	5541.2629	61	5 4 2	6 4 3	4.22E-05	15	120
5496.05137	15	12 1 11	11 1 10	1.69E-03	5	200	5541.95258	0	7 3 4	6 2 5	2.56E-04	4	200
5496.2573	-27	3 1 4 7	1 0 4 6	9.03E-04	7	200	5544.36000	-73	5 3 2	4 1 3	2.09E-04	3	200
5497.7244	36	12 2 11	11 1 10	1.16E-04	4	200	5546.09302	-15	2 1 1	1 1 0	6.05E-04	3	120
5499.59631	0	1 2 5 7	1 1 5 6	2.30E-04	3	200	5546.3476	0	4 1 3	4 0 4	3.79E-05	10	120
5499.90836	29	1 1 2 9	1 0 2 8	2.16E-03	2	200	5547.20148	-21	6 4 3	5 3 2	3.30E-04	7	200
5500.39357	19	12 3 10	1 1 3 9	8.76E-04	3	200	5547.8471	-5	9 6 3	8 4 4	3.51E-05	10	011
5501.31925	6	5 2 3	4 1 4	1.95E-04	6	200	5548.01216	-12	6 4 2	5 3 3	3.22E-04	3	200
5501.5274	-2	1 2 4 9	1 1 4 8	5.16E-04	2	200	5549.87781	17	6 2 4	6 2 5	7.40E-05	4	120
5501.61608	-5	13 2 12	12 2 11	9.23E-04	2	200	5550.93117	11	3 0 3	2 0 2	1.09E-03	2	120
5501.9885	0	7 2 6	7 2 5	3.58E-05	15	120	5551.0573	59	4 3 2	3 1 3	9.80E-05	4	200
5502.24125	-9	13 1 12	12 1 11	8.02E-04	4	200	5552.71915	-13	3 1 3	2 1 2	9.66E-04	3	120
5502.55213	0	1 1 3 8	1 0 3 7	1.56E-03	4	200	5553.68359	-3	6 3 3	5 1 4	2.59E-04	4	200
5504.7215	3	1 0 5 6	9 3 7	7.48E-05	4	011	5553.7791	-25	5 1 4	5 1 5	4.81E-05	10	120
5504.8571	-27	5 3 3	4 2 2	4.09E-04	10	200	5555.2509	25	4 0 4	3 1 3	1.99E-05	15	120
● 5505.1945	-20	9 9 1	8 8 0	6.7014-05	10	011	5556.0447	-6	4 4 0	5 4 1	5.99E-05	6	120
● 5505.9928	-6	1 1 8 4	1 0 7 3	3.45E-05	10	011	5556.0595	0	4 4 1	5 4 2	6.23E-05	6	120
5506.1893	-68	1 2 4 8	1 1 4 7	4.57E-04	4	200	5556.8668	-2	7 2 5	6 1 6	7.85E-05	6	200
5506.24966	2	12 2 10	1 1 2 9	9.77E-04	3	200	5557.21843	-14	7 4 4	6 3 3	2.83E-04	4	200
● 5506.85583	0	15 0 15	14 0 14	7.40E-04	5	200	5557.6985	39	5 1 4	5 0 5	2.75E-05	10	120
5507.11375	0	13 3 11	12 3 10	3.88E-04	7	200	5559.18768	-7	7 2 5	6 0 6	2.16E-04	4	200
5509.01687	2	1 1 1	1 1 0	6.40E-04	3	120	5559.60709	-3	7 4 3	6 3 4	2.72E-04	3	200
5510.0728	-44	12 2 10	11 0 11	2.75E-05	10	011	5560.5507	110	6 3 3	5 4 2	1.60E-05	15	120
5511.2278	-80	7 4 3	8 4 4	2.32E-05	10	120	5561.1178	19	8 3 5	7 2 6	1.49E-04	5	200
5511.28083	0	1 2 3 9	1 1 3 8	7.02E-04	3	200	5561.8177	-11	7 2 5	7 2 6	2.99E-05	10	120
5511.62175	0	13 2 11	12 2 10	4.23E-04	4	200	● 5562.81106	74	5 5 1	4 4 0	4.67E-04	3	200
5511.9261	1	7 4 4	8 4 5	1.46E-05	10	120	5563.14547	-8	3 1 2	2 1 1	9.25E-04	3	120
5512.32540	0	16 1 16	15 1 15	3.1514-04	4	200	5563.9653	-48	8 3 6	8 3 5	2.29E-05	10	120
5512.6607	-14	6 2 5	6 2 4	7.70E-05	6	120	5564.3120	68	4 0 4	3 0 3	1.41E-03	5	120
5513.04464	18	6 3 4	5 2 3	3.82E-04	3	200	5565.3979	0	8 4 5	7 3 4	1.9143-04	5	200
5514.7916	0	1 1 0	1 1 1	6.20E-04	10	120	5565.45543	-1	4 1 4	3 1 3	1.07E-03	3	120
● 5517.3304	0	17 0 17	16 0 16	2.25E-04	6	200	5569.5721	0	5 2 3	5 1 4	3.76E-05	10	120
5518.0626	-7	6 4 3	6 2 4	3.79E-05	10	200	5569.67988	41	6 3 4	6 3 3	1.05E-04	3	120
5518.69339	-6	13 3 10	1 2 3 9	2.88E-04	3	200	5569.87587	0	3 3 1	3 3 0	6.62E-04	2	120
5519.2201	52	6 3 4	7 2 5	1.42E-05	10	120	5569.92228	20	3 3 0	3 3 1	6.61E-04	3	120
● 5519.6769	28	1 0 9 2	9 8 1	2.97E-05	10	011	5570.53017	4	4 3 1	4 3 2	3.55E-04	4	120
5520.0107	-39	7 6 1	6 4 2	4.25E-04	10	011	5571.15245	0	8 4 4	7 3 5	2.35E-04	3	200
5520.0915	56	7 6 2	6 4 3	4.02E-04	6	011	5571.3801	-11	3 2 1	3 1 2	3.96E-05	10	120
5520.7432	5	5 2 4	5 2 3	1.45E-04	3	120	5571.53985	-3	5 3 2	5 3 3	1.93E-04	2	120
5522.1214	-5	1 1 5 7	1 0 3 8	3.07E-05	6	011	5573.8885	75	2 2 0	2 1 1	2.41E-05	10	120
5522.3821	-40	7 3 4	7 1 7	3.86E-05	10	200	5574.9554	24	1 1 4 8	1 0 3 7	4.47E-05	10	200
5523.2110	-56	12 3 10	1 1 2 9	4.65E-05	10	200	5576.3796	21	7 3 4	7 3 5	4.65E-05	10	120
5523.51458	1	4 4 1	3 3 0	3.50E-04	10	200	5576.5944	34	1 1 6 6	1 0 4 7	2.09E-05	10	011
5523.54368	-10	4 4 0	3 3 1	3.42E-04	3	200	5576.85138	7	5 0 5	4 0 4	1.05E-03	3	120
5523.8480	8	11 3 9	1 0 2 8	8.30E-05	10	200	5577.33288	3	3 2 2	2 2 1	4.77E-04	2	120
5524.0277	14	9 3 7	8 2 6	1.71E-04	4	200	5577.6270	-32	8 3 5	7 1 6	1.92E-04	4	200
5524.33482	-11	1 0 3 8	9 2 7	1.14E-04	10	200	5577.70586	-2	5 1 5	4 1 4	1.01E-03	2	120
5525.1688	71	3 3 0	2 1 1	8.48E-05	10	200	5578.57242	-4	3 2 1	2 2 0	4.73E-04	2	120
5525.28352	21	6 3 3	5 2 4	3.42E-04	4	200	5580.04249	-2	4 1 3	3 1 2	1.01E-03	2	120
5526.1614	10	4 2 3	4 2 2	2.88E-04	3	120	5581.4507	-46	8 3 5	8 3 6	2.28E-05	10	120
5526.5455	-21	6 4 3	7 4 4	3.27E-05	10	120	5581.6234	29	2 2 1	2 1 2	2.45E-05	10	120
5528.93916	0	3 1 2	3 1 3	1.58E-04	3	120	5583.14788	6	9 4 5	8 3 6	1.18E-04	4	200
5529.1940	-38	3 2 2	3 2 1	4.52E-04	15	120	5583.3461	1	9 3 6	8 2 7	4.20E-05	5	200
5530.48095	3	2 2 1	2 2 0	1.00E-03	4	120	5583.9316	-27	5 1 5	4 0 4	4.20E-05	10	120
5531.14597	-5	2 2 0	2 2 1	9.90E-04	4	120	5584.8246	1	6 0 6	5 1 5	8.30E-05	10	120
5531.44347	4	6 2 4	5 0 5	4.47E-04	5	200	5585.44820	6	7 5 3	6 4 2	1.95E-04	3	200
5532.45246	-8	3 2 1	3 2 2	5.32E-04	4	120	5585.53320	46	7 5 2	6 4 3	1.91E-04	3	200
5533.2015	-21	3 3 1	2 1 2	4.90E-05	10	200	5585.8679	-29	3 2 2	3 1 3	3.17E-05	10	120
5534.2149	-16	8 6 2	7 4 3	4.40E-05	10	011	5588.74335	0	6 0 6	5 0 5	8.50E-04	4	120
5534.5001	-12	8 6 3	7 4 4	3.22E-05	10	011	5589.0350	29	8 2 6	7 1 7	4.17E-05	10	200
5535.1522	-7	4 3 1	3 1 2	1.53E-04	4	200	5589.47018	13	6 1 6	5 1 5	8.33E-04	2	120
5535.53475	-15	4 2 2	4 2 3	2.81E-04	3	120	5591.17423	-21	6 3 4	5 1 5	1.01E-04	8	200
5535.8454	12	5 4 2	4 3 1	3.30E-04	10	200	5592.60836	-6	4 2 3	3 2 2	6.66E-04	3	120
5536.04880	17	5 4 1	4 3 2	3.38E-04	4	200	5593.38852	-29	6 1 6	5 0 5	8.25E-05	3	120
5536.64720	-23	2 0 2	1 0 1	8.58E-04	3	120	5594.7295	-4	9 3 6	8 1 7	1.04E-04	10	200
5536.6939	-41	7 4 3	7 2 6	2.2614-05	15	200	● 5594.9720	355	8 7 1	7 5 2	2.23E-05	15	011
5536.9510	-17	9 5 5	8 2 6	3.31E-05	10	011	5595.51166	-43	4 2 2	3 2 1	6.80E-04	10	120
5538.0002	38	3 1 2	3 0 3	9.81E-05	10	120	5595.5566	0	8 5 4	7 4 3	3.61E-03	4	200

Table 3. continued

observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength	%s	R	band	observed position	0-c	upper J K <sub>a</sub> K <sub>c</sub>	lower J K <sub>a</sub> K <sub>c</sub>	observed strength	%s	R	band
5595.8546	-12	8 5 3	7 4 4	1.30E-04	15		200	5641.3294	-26	11 0 11	10 0 10	6.70E-05	5		120
5596.66058	-8	5 1 4	4 1 3	9.14E-04	4		120	5641.5269	4	11 1 11	10 1 10	6.20E-05	5		120
5597.8385	10	7 0 7	6 1 6	1.23E-04	5		120	5641.7138	9	11 1 11	10 0 10	6.70E-05	10		120
5598.8728	-33	5 2 4	5 1 5	3.30E-05	10		120	5642.0063	-34	7 4 4	6 2 5	6.23E-05	10		200
5599.5035	71	4 4 0	3 2 1	3.50E-05	15		200	5642.1672	43	1 1 4 7	1 0 2 8	2.23E-05	10		200
● 5600.06B43	219	6 6 0	5 5 1	2.45E-04	4		200	5643.9374	9	8 1 7 7	1 6	3.40E-04	4		120
5600.13927	-6	7 0 7	6 0 6	6.33E-04	4		120	● 5645.4336	85	8 7 2	7 6 1	8.35E-05	4		200
5600.76377	-5	7 1 7	6 1 6	6.31E-04	4		120	5645.8804	-69	3 3 0	3 2 1	1.43E-05	6		120
5601.1774	60	4 4 1	3 2 2	2.96E-05	6		200	5647.5388	70	3 3 1	3 2 2	1.39E-05	6		120
5603.0648	5	7 1 7	6 0 6	1.02E-04	4		120	5647.6147	44	9 1 8	8 2 7	2.74E-05	10		120
5605.5284	-3	9 5 4	8 4 5	9.75E-05	5		200	5640.69618	0	7 2 5	6 2 4	4.09E-04	3		120
5606.2558	46	7 1 6	6 2 5	2.98E-05	10		120	5648.8458	25	4 3 2	4 2 3	2.68E-05	10		120
5607.5935	-65	6 2 5	6 1 6	1.92E-05	15		120	5649.20940	-8	5 3 3	4 3 2	2.75E-04	2		120
5607.69588	-20	5 2 4	4 2 3	6.84E-04	2		120	5649.52827	-1	5 3 2	4 3 1	2.77E-04	2		120
5608.8576	-13	1 0 3 7	9 2 8	3.50E-05	10		200	5651.0597	-52	5 3 3	5 2 4	2.53E-05	15		120
5609.6998	3	5 4 1	4 2 2	5.15E-05	6		200	5651.69945	-2	8 2 7	7 2 6	3.00E-04	2		120
5609.8114	14	8 0 8	7 1 7	1.1 OE-04	3		120	● 5654.8072	-6	9 7 2	8 6 3	5.45E-05	5		200
● 5610.9894	-58	7 6 1	6 5 2	2.15E-04	10		200	5656.932	-60	8 4 5	7 2 6	4.50E-05	10		200
5611.09542	0	8 0 8	7 0 7	4.1513-04	5		120	5658.9975	-21	9 1 8	8 1 7	1.96E-04	3		120
5611.2244	44	1 1 4 7	1 0 3 8	3.94E-05	10		200	● 5663.4472	-13	1 0 7 4	9 6 3	4.54E-05	10		200
5611.6036	-11	8 1 8	7 1 7	4.15E-04	3		120	5663.9088	-32	9 3 7	8 1 8	2.98E-05	10		200
5612.3811	15	1 0 5 6	9 4 5	5.73E-05	4		200	5665.67677	-43	6 3 4	5 3 3	2.46E-04	2		120
5613.73412	1	7 3 5	6 1 6	7.35E-05	6		200	5665.99630	6	9 2 8	8 2 7	1.70E-04	3		120
5614.4807	-18	5 4 2	4 2 3	4.86E-05	10		200	5666.41228	0	6 3 3	5 3 2	2.54E-04	4		120
5614.6763	-65	1 0 5 9	4 2 6	5.85E-05	3		200	5666.6551	34	1 0 1 9	9 2 8	2.43E-05	10		120
5616.2196	-37	1 0 3 7	9 1 8	4.67E-05	10		200	5666.69938	10	8 2 6	7 2 5	2.54E-04	3		120
5618.4268	53	1 1 5 7	1 0 4 6	4.11E-05	10		200	5668.2080	-118	8 2 7	7 1 6	2.19E-05	15		120
● 5621.2027	315	8 6 3	7 5 2	1.63E-04	4		200	● 5668.7432	28	8 8 1	7 7 0	2.73E-05	10		200
5621.6156	0	9 0 9	8 0 8	2.59E-04	4		120	5674.0168	-20	1 0 1 9	9 1 8	1.00E-04	3		120
5622.00437	-9	9 1 9	8 1 8	2.49E-04	3		120	5677.3791	-59	9 2 8	8 1 7	2.24E-05	10		120
5622.57350	18	6 2 5	5 2 4	5.78E-04	4		120	*5677.9514	-49	9 8 2	8 7 1	2.32E-05	10		200
5622.6959	7	9 1 9	8 0 8	1.11E-04	4		120	5680.1704	12	1 0 2 9	9 2 8	9.30E-05	3		120
5623.3938	4	9 2 7	8 1 8	2.34E-05	10		200	5680.3514	-1	6 5 1	5 3 2	2.38E-05	10		200
5623.5724	-28	7 4 3	6 2 4	5.15E-05	10		200	5681.0951	0	6 5 2	5 3 3	2.48E-05	10		200
5624.0849	-23	9 2 7	8 0 8	4.48E-05	10		200	5682.23355	0	7 3 5	6 3 4	2.02E-04	2		120
5627.4271	-50	8 1 7	7 2 6	3.08E-05	10		120	56 B3.6204	-9	7 3 4	6 3 3	1.94E-04	3		120
5627.9334	-26	8 4 4	7 2 5	7.1 OB-05	4		200	5689.0946	29	11 1 10	1 0 1 9	4.63E-05	10		120
5627.9751	-5	6 4 3	5 2 4	5.80E-05	8		200	5689.7598	-7	7 5 2	6 3 3	2.38E-05	10		200
5628.62363	-12	7 1 6	6 1 5	5.38E-04	3		120	5690.7026	9	10. 4 7	9 2 8	2.29E-05	10		200
5628.9189	-8	1 2 4 8	1 1 3 9	2.78E-05	10		200	5691.9041	-8	7 5 3	6 3 4	2.21E-05	10		200
5628.9189	-76	8 2 7	8 1 8	2.78E-05	15		120	5694.2676	0	11 2 10	1 0 2 9	4.63E-05	10		120
5628.9712	37	9 3 6	9 2 7	4.89E-05	15		120	5698.8569	43	8 3 6	7 3 5	1.27E-04	3		120
5630.75820	-17	6 2 4	5 2 3	5.75E-04	3		120	5701.10968	16	8 3 5	7 3 4	1.29E-04	3		120
5631.6920	-9	10 0 10	9 0 9	1.54E-04	4		120	5703.16370	0	1 0 2 8	9 2 7	7.17E-05	6		120
5631.97710	-4	10 1 10	9 1 9	1.34E-04	3		120	● 5712.8269	300	5 4 2	4 4 1	1.09E-04	3		120
5632.86350	-23	4 3 2	3 3 1	2.20E-04	4		120	5715.54202	0	9 3 7	8 3 6	7.88E-05	5		120
5632.96616	-1	4 3 1	3 3 0	2.27E-04	3		120	571 8.8191	-38	9 3 6	8 3 5	8.1 OB-05	6		120
● 5633.97457	7	4 4 0	4 4 1	4.48E-04	4		120	5729.6272	18	6 4 3	5 4 2	6.60E-05	3		120
5634. 8940	-16	5 4 2	5 4 1	1.15E-04	5		120	5729.6478	0	6 4 2	5 4 1	6.56E-05	3		120
5634.9180	0	5 4 1	5 4 2	1.13E-04	3		120	5732.2953	0	1 0 3 8	9 3 7	4.15E-05	4		120
● 5635.3481	42	7 7 1	6 6 0	9.1 OB-05	10		200	5736.7411	0	1 0 3 7	9 3 6	4.14E-05	10		120
5635.8991	2	6 4 3	6 4 2	5.80E-05	3		120	5746.5985	0	7 4 4	6 4 3	6.30E-05	8		120
5637.23645	-1	7 2 6	6 2 5	4.12E-04	4		120	5746.6523	106	7 4 3	6 4 2	5.90E-05	10		120
5637.2980	13	7 4 3	7 4 4	2.31E-05	10		120	5763.6980	0	8 4 5	7 4 4	3.77E-05	10		120
5638.0216	47	8 3 6	7 1 7	4.83E-05	10		200	5763.8007	-30	8 4 4	7 4 3	3.99E-05	10		120
5639.4249	-20	1 0 6 4	9 5 5	3.63E-05	10		200	5780.8942	0	9 4 6	8 4 5	2.65E-05	7		120
5641.1432	39	11 0 11	10 1 10	7.20E-05	8		120	5781.0377	0	9 4 5	8 4 4	2.50E-05	7		120
5641.21107	12	5 3 2	5 2 3	2.41E-05	10		120	● 5843.0735	0	6 5 2	5 5 1	2.12E-05	10		120

1. strengths given in units of  $\text{cm}^{-2}/\text{atm.}$  at 296K and normalized to an abundance of 100% HDO

● asterisk denotes a doubled absorption with the quantum assignment given for one of the transitions. The strength given represents the sum of the strengths of the two comparable transitions.

o-c are observed minus computed line positions in  $\text{cm}^{-1} \times 10^5$ . Computed values derived from energy levels given in table 2 and ground state levels given in ref. 5. The (021)-(010) computed positions were derived from levels for the (021) given in ref. 4 and the (010) levels given in ref. 5

%s are estimated uncertainties in the measured line strengths given in percent

R is the ratio of the observed line strength derived in this study to the values given in the HITRAN listing, ref. 3.