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THE HITRAN MOLECULAR DATABASE: EDITIONS OF 1991 AND 1992

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Abstract—We describe in this paper the modifications, improvements, and enhancements to the HITRAN molecular absorption database that have occurred in the two editions of 1991 and 1992. The current database includes line parameters for 31 species and their isotopomers that are significant for terrestrial atmospheric studies. This line-by-line portion of HITRAN presently contains about 709,000 transitions between 0 and 23,000 cm^{-1} and contains three molecules not present in earlier versions: COF_2, SF_6, and H_2S. The HITRAN compilation has substantially more information on chlorofluorocarbons and other molecular species that exhibit dense spectra which are not amenable to line-by-line representation. The user access of the database has been advanced, and new media forms are now available for use on personal computers.

INTRODUCTION

Almost 20 yr have passed since the first atmospheric absorption line parameters compilation[1] was created on machine-readable magnetic tape. Since that time there has been a continual program to update, enhance, extend, and improve this database.[2,3] The molecular spectroscopic database, known under the acronym HITRAN, has been established to provide the necessary fundamental parameters to represent molecular properties in atmospheric spectroscopic analyses. On a very simple level, this database includes the wavenumber (in cm^{-1}), the intensity [in cm^{-1}/(molecule $-\ cm^{-2}$)], the Lorentzian halfwidth (in cm^{-1}/atm), and the lower state energy (in cm^{-1}) of each transition. This basic set of parameters was instituted based on the requirements for Lambert–Beer law calculations, which was the primary use of this database. The units for intensity were established on this consideration, where atmospheric slant paths would provide a multiplicative column density. The intensity and halfwidth were to be reported at a standard temperature of 296 K on the compilation, and the halfwidths were chosen to be the air-broadened values. An intensity cutoff criterion was also established: all transitions that yielded at least a 10% absorption through a space-to-space limb-viewing atmospheric path in local thermodynamic equilibrium (LTE) tangent to the surface would be retained. The early databases often were forced to adopt default values for the halfwidths of transitions because of the lack of information at that time.

The initial database contained only the seven most infrared-active gases: H_2O, CO_2, O_3, N_2O, CO, CH_4, and O_2. It was straightforward to set the minimum intensity criterion for the uniformly-mixed gases, and fairly easy for the two variable gases, water vapor and ozone. Subsequent editions

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of HITRAN have added many trace atmospheric species, as well as molecular bands involved in upper atmospheric non-LTE processes. For these special cases, the intensity cutoff has been lowered. One finds, therefore, that presently HITRAN contains transitions that serve specific atmospheric problems beyond the scope of the original database.[1] In fact the database has grown from the original seven gases to 31; from some 100,000 transitions to over 709,000; from coverage of the original spectral range of 100 to 1 μm (100 to 10,000 cm^{-1}) to the present 0 to 23,000 cm^{-1}; and from a limited set of parameters (in an 80 character "card image" format) to the current 19-parameter set (100 bytes per transition).

Table 1. Summary of molecular species on HITRAN.

Molecule	Isotopes	# of Bands	# of Lines
H_2O	4	134	48 523
CO_2	8	592	60 790
O_3	3	76	168 881
N_2O	5	140	24 125
CO	5	31	3 600
CH_4	3	48	47 415
O_2	3	18	2 254
NO	3	13	7 385
SO_2	2	7	26 225
NO_2	1	9	55 468
NH_3	2	9	5 817
HNO_3	1	13	143 021
OH	3	27	8 676
HF	1	6	107
HCl	2	17	371
HBr	2	16	398
HI	1	9	237
ClO	2	8	6 020
OCS	4	6	737
H_2CO	3	10	2 702
HOCl	2	6	15 565
N_2	1	1	120
HCN	3	8	772
CH_3Cl	2	6	6 687
H_2O_2	1	2	5 444
C_2H_2	2	9	1 258
C_2H_6	1	2	4 749
PH_3	1	2	2 886
COF_2	1	7	46 894
SF_6	1	1	11 520
H_2S	1	1	661

This paper describes the updates and modifications since the previous edition[3] of 1986. There have been two releases of the HITRAN compilation: February 1991 and March 1992, and the following sections summarize the updates for both versions. The bulk of the changes went into the 1991 edition. Table 1 is a summary of the molecular species that are currently represented in the line-parameter portion of the compilation. Table 2 provides a more detailed statistical view of the bands in HITRAN that may have undergone modifications since the last edition.[3] This table is partitioned by isotopomer and defines the abbreviated isotope code used in HITRAN listings and in the following sections. For each isotopomer, statistics are provided for each band, ordered by bandcenter, ν_0 (cm^{-1}), in the first column. No bandcenter value is given for the pure rotation bands nor for unidentified collections of lines, such as still exists for water vapor and methane. The second column gives the upper and lower vibrational states, the third column gives the range of the wavenumbers, and the fourth column gives the number of lines. The fifth column presents a summation of the intensities of these lines, ΣS; this summation does not necessarily represent the integrated band intensity, such as in cases where the HITRAN cutoff limits the number of lines. Columns 6 and 7 give the minimum and maximum intensity values found, and finally the last column gives the maximum total rotational quantum number, J''_{max}, present on HITRAN. A table including all the species on the current HITRAN, with additional information on extrema of other parameters for each band, can be obtained from the first author. Table 3 summarizes the cross-section data, which have been substantially enhanced in the 1991 and 1992 editions.

In contrast to the 1986 edition, where error codes and the three reference indices for the line position, intensity, and air-broadened halfwidth were not implemented for most lines, effort has been made to include values in these fields for most of the revised or new lines. The error code criteria are shown in Table 4. The file structure of HITRAN remains the same as in the 1986 edition (see Fig. 1). The third file contains the references by molecule and parameter as well as references to the cross-section data, the values of isotopic abundance assumed for the isotopomers in HITRAN, and the error codes. A zero or null index for the reference indicates data carried over from previous compilations.

The spectral coverage for the new HITRAN has been extended towards shorter wavelengths, due to the addition of water vapor parameters in the visible. Three new molecular species have also been added: COF_2 and SF_6 in 1991, and H_2S in 1992. In addition, there have been many new bands for some of the species as described in the following sections; thus the total number of lines on the main portion of the database has increased to 709,308. Likewise, the number of species, bands, and temperature samples of the cross-section data has increased.

The first file on the compilation contains the FORTRAN source code for the SELECT program. This program has been enhanced to provide the user not only with the ability to select portions of the database under criteria of wavenumber range, molecule, isotope, vibrational band, and intensity cutoff, but also with a choice to recast the intensities to temperatures other than the standard of the database, 296 K. SELECT also provides a platform for converting to or from the vibrational indices (global quanta) in HITRAN from or to the more common spectroscopic notation. Vibrational indices have been extended in some cases due to new bands occurring in HITRAN; these should be transparent to the user. The descriptors unique to a transition, such as the rotational quantum numbers and symmetry symbols (which we call the "local" identification), are broken up into six classes as shown in Table 5. The set of descriptors for each class is the most general one, encompassing the maximum necessary for any one species (for example, the quantum number of hyperfine splitting, F, is only occasionally encountered).

There are several caveats for the use of HITRAN that need to be stressed. There are some transitions on the database (for example with methane and short wavelength water vapor) whose quantum identifications are not fully known. The lines represent empirically determined positions and intensities without determined lower state energies. We continue to flag these transitions with a *minus one* ($-1.$) in the lower state energy field (an exception is methane where some artificial estimates of 333.3333 and 555.5555 cm^{-1} were introduced). The fields of the format for each transition are the same as the previous edition and are shown and defined in Table 6.

In the newer editions, the parameter for the transition probability squared has been properly implemented.[4] However, there are two species, oxygen and ethane, for which the total partition sum was not calculated and consequently a value of zero has been assigned for this parameter.

Table 2. Summary of bands on HITRAN.

ν_o	v' - v"	ν_{min} - ν_{max}	#lines	ΣS	S_{min}	S_{max}	J''_{max}
Total Number of lines for the $H_2{}^{16}O$ (161) isotope is: 30,117							
	000 - 000	0 - 1648	1728	5.268E-17	1.010E-32	2.670E-18	23
	010 - 010	0 - 1030	750	2.225E-20	1.020E-29	1.120E-21	19
	020 - 020	26 - 503	129	1.016E-23	1.010E-26	5.340E-25	11
	100 - 100	86 - 302	27	5.977E-25	1.010E-26	5.080E-26	8
	001 - 001	86 - 292	19	3.072E-25	1.010E-26	3.140E-26	6
1515.163	030 - 020	1271 - 1932	121	5.135E-24	1.030E-26	1.660E-25	9
1556.883	020 - 010	945 - 2407	728	9.709E-21	1.000E-26	2.880E-22	15
1594.7498	010 - 000	782 - 2910	1763	1.058E-17	1.000E-26	2.920E-19	20
2062.306	100 - 010	1221 - 2520	402	1.820E-22	1.020E-26	5.340E-24	13
2161.183	001 - 010	1298 - 2612	365	2.626E-22	1.010E-26	1.000E-23	13
3072.046	030 - 010	2813 - 3917	313	7.303E-23	1.000E-26	1.830E-24	12
3151.630	020 - 000	2565 - 4339	1132	7.571E-20	1.000E-26	3.570E-21	17
3640.245	110 - 010	3172 - 4145	365	1.946E-22	1.000E-26	1.250E-23	13
3657.053	100 - 000	2823 - 4347	1302	4.955E-19	1.010E-26	2.080E-20	18
3719.891	021 - 020	3570 - 3869	49	1.158E-24	1.010E-26	5.110E-26	7
3736.522	011 - 010	3203 - 4282	527	2.923E-21	1.010E-26	9.810E-23	15
3755.930	001 - 000	2894 - 4350	1546	7.200E-18	1.000E-26	2.290E-19	19
4666.793	030 - 000	4250 - 5932	662	3.955E-22	2.910E-27	4.210E-23	16
5234.977	110 - 000	4602 - 6006	991	3.716E-20	3.230E-27	3.600E-21	16
5276.776	021 - 010	4908 - 5812	285	6.620E-22	3.850E-27	2.620E-23	10
5331.269	011 - 000	4609 - 6255	1306	8.042E-19	3.100E-27	2.760E-20	18
6134.030	040 - 000	5904 - 7190	218	1.798E-23	1.000E-26	8.560E-25	12
6775.10	120 - 000	6227 - 7522	614	2.474E-21	3.100E-27	1.410E-22	13
6779.08	031 - 010	6572 - 7012	98	3.029E-23	1.490E-26	1.340E-24	10
6871.51	021 - 000	6205 - 7804	946	3.807E-20	3.000E-27	1.120E-21	17
7200.	210 - 010	6900 - 7361	43	1.364E-23	3.000E-26	2.950E-24	9
7201.54	200 - 000	6446 - 7940	988	6.120E-20	3.000E-27	1.400E-21	15
7213.26	111 - 010	6932 - 7388	93	1.170E-22	1.180E-26	6.590E-24	11
7249.811	101 - 000	6489 - 8051	1366	5.634E-19	3.000E-27	2.100E-20	19
7445.07	002 - 000	6657 - 8183	864	3.657E-21	3.000E-27	1.750E-22	13
7552.0	050 - 000	8134 - 8866	8	2.738E-24	4.263E-26	1.000E-24	7
8238.84	041 - 010	8083 - 8506	77	1.207E-24	3.630E-27	5.110E-26	8
8273.976	130 - 000	8057 - 9127	205	4.135E-22	4.212E-26	1.030E-22	11
8373.853	031 - 000	8073 - 9241	294	1.250E-21	1.170E-26	3.243E-23	13
8733.985	121 - 010	8533 - 8969	62	2.921E-23	2.528E-26	2.454E-24	8
8761.582	210 - 000	8328 - 9298	189	1.454E-21	1.744E-26	3.510E-22	11
8807.000	111 - 000	8283 - 9471	587	3.546E-20	8.550E-27	1.174E-21	16
8890.	060 - 000	8469 - 9076	7	1.232E-22	2.711E-25	9.012E-23	7
9000.136	012 - 000	8584 - 9482	347	7.503E-22	1.334E-26	2.479E-23	11
9833.584	041 - 000	9603 - 10529	163	3.051E-23	7.890E-27	1.030E-24	11
10284.367	220 - 000	9933 - 10685	109	1.245E-22	9.480E-27	4.440E-23	9
10328.731	121 - 000	9767 - 11077	393	2.159E-21	7.490E-27	9.000E-23	12
10524.3	022 - 000	10187 - 10962	51	3.686E-23	2.210E-26	1.510E-23	9
10599.686	300 - 000	9942 - 11261	383	2.108E-21	6.150E-27	3.570E-22	11
10613.355	201 - 000	9975 - 11181	572	1.704E-20	7.210E-27	5.420E-22	15
10868.876	102 - 000	10028 - 11322	342	5.742E-22	8.300E-27	1.790E-23	11
11032.406	003 - 000	10418 - 11481	400	1.905E-21	6.820E-27	5.930E-23	12
11813.19	131 - 000	11522 - 12373	222	3.771E-23	3.000E-27	1.220E-24	10
12139.2	310 - 000	11808 - 12456	224	4.830E-23	3.000E-27	7.440E-24	9
12151.26	211 - 000	11689 - 12697	471	1.203E-21	3.000E-27	4.210E-23	14
12407.64	112 - 000	12055 - 12753	215	4.765E-23	3.000E-27	4.580E-24	9
12565.00	013 - 000	12249 - 12938	251	8.924E-23	3.000E-27	2.900E-24	11

[continued . . .]

Table 2—*continued*

ν_o	$v' - v''$	$\nu_{min} - \nu_{max}$	#lines	ΣS	S_{min}	S_{max}	J''_{max}
13256.	141 - 000	13238 - 13937	42	3.071E-24	8.237E-27	4.215E-25	9
13448.	042 - 000	13319 - 13942	12	2.947E-24	1.104E-26	1.746E-24	10
13642.202	320 - 000	13480 - 13940	17	5.836E-24	1.350E-26	1.534E-24	8
13652.656	221 - 000	13322 - 14163	220	1.639E-22	8.328E-27	5.200E-24	11
13828.277	202 - 000	13352 - 14143	195	8.463E-23	8.616E-27	6.461E-24	12
13830.938	301 - 000	13331 - 14217	336	1.074E-21	1.119E-26	3.500E-23	14
13910.896	122 - 000	13549 - 14138	44	3.318E-24	1.394E-26	2.079E-25	7
14066.194	023 - 000	13932 - 14425	68	7.815E-24	2.025E-26	6.264E-25	7
14221.161	400 - 000	13958 - 14617	178	4.320E-23	1.788E-26	1.224E-24	10
14318.813	103 - 000	13926 - 14657	239	1.983E-22	8.962E-27	6.568E-24	12
14536.87	004 - 000	14137 - 14703	50	2.665E-24	5.833E-27	8.784E-25	7
14640.	151 - 000	14922 - 15220	2	4.602E-26	7.420E-27	3.860E-26	8
15107.	330 - 000	15250 - 15415	3	2.422E-25	2.164E-26	1.740E-25	4
15119.029	231 - 000	14957 - 15520	92	5.751E-24	9.387E-27	3.656E-25	8
15344.503	212 - 000	15084 - 15667	99	1.450E-23	1.540E-26	1.407E-24	9
15347.956	311 - 000	15019 - 15724	211	8.830E-23	1.581E-26	2.604E-24	12
15742.795	410 - 000	15570 - 15939	37	1.287E-24	9.370E-27	2.071E-25	6
15832.765	113 - 000	15601 - 15965	105	1.562E-23	9.682E-27	5.867E-25	9
16821.635	321 - 000	16551 - 17168	134	4.219E-23	1.747E-26	1.894E-24	10
16825.23	222 - 000	16642 - 17108	39	6.014E-24	1.676E-26	7.962E-25	7
16898.4	302 - 000	16595 - 17076	118	2.017E-23	1.699E-26	2.111E-24	11
16898.842	203 - 000	16548 - 17181	205	8.754E-23	1.435E-26	2.811E-24	12
17227.7	420 - 000	17140 - 17281	2	2.749E-26	1.032E-26	1.717E-26	4
17312.539	123 - 000	17167 - 17583	53	1.529E-24	6.937E-27	9.012E-26	7
17458.354	500 - 000	17179 - 17637	88	3.795E-24	1.033E-26	2.328E-25	9
17495.528	401 - 000	17221 - 17724	137	1.742E-23	1.057E-26	6.857E-25	10
17748.073	104 - 000	17504 - 17765	5	6.381E-26	1.054E-26	1.424E-26	4
18265.820	331 - 000	18122 - 18434	63	2.196E-24	7.259E-27	1.527E-25	6
18320.	232 - 000	18175 - 18321	2	3.282E-26	7.279E-27	2.554E-26	4
18392.974	312 - 000	18275 - 18465	15	6.845E-25	2.557E-26	9.816E-26	5
18393.314	213 - 000	18199 - 18505	62	5.895E-24	1.862E-26	3.047E-25	7
18989.961	411 - 000	18843 - 19067	20	5.554E-25	1.155E-26	4.944E-26	6
19720.	421 - 000	19617 - 19773	6	3.549E-25	2.773E-26	1.349E-25	4
19781.105	303 - 000	19515 - 19932	88	1.353E-23	1.988E-26	6.270E-25	9
19795.	402 - 000	19530 - 19881	29	3.576E-24	1.208E-26	6.939E-25	8
20543.137	501 - 000	20389 - 20620	27	6.025E-25	8.175E-27	4.763E-26	6
21221.569	412 - 000	21160 - 21272	9	1.154E-25	4.251E-27	2.524E-26	3
21221.828	313 - 000	21078 - 21305	25	5.917E-25	4.276E-27	4.798E-26	5
22529.445	403 - 000	22341 - 22597	29	1.851E-24	2.772E-26	1.513E-25	6
	- 000	10103 - 11224	71	7.903E-23	1.170E-25	2.430E-23	
	-	8036 - 22657	1628	1.899E-22	3.420E-27	1.140E-23	
Total Number of lines for the $H_2{}^{18}O$ (181) isotope is: 6,357							
	000 - 000	6 - 977	766	1.066E-19	1.020E-26	5.390E-21	18
	010 - 010	21 - 559	202	4.632E-23	1.020E-26	2.350E-24	12
1550.774	020 - 010	1265 - 1990	262	1.982E-23	4.080E-27	5.900E-25	11
1588.279	010 - 000	949 - 2268	968	2.149E-20	4.040E-27	6.160E-22	17
2153.288	001 - 010	2066 - 2267	16	2.267E-25	1.010E-26	2.080E-26	5
3139.053	020 - 000	2806 - 4046	388	1.325E-22	1.010E-26	4.530E-24	13
3632.961	110 - 010	3624 - 3790	3	7.920E-26	1.510E-26	3.530E-26	4
3649.685	100 - 000	3108 - 4194	553	9.468E-22	1.000E-26	7.770E-23	14
3722.189	011 - 010	3525 - 3912	101	5.356E-24	1.010E-26	1.930E-25	9
3741.567	001 - 000	3160 - 4341	711	1.393E-20	1.000E-26	4.370E-22	16

[*continued*. . .]

Table 2—*continued*

ν_o	$\nu' - \nu''$	$\nu_{min} - \nu_{max}$	#lines	ΣS	S_{min}	S_{max}	J''_{max}
5221.24	110 - 000	4791 - 5728	443	5.646E-23	1.000E-27	7.130E-24	12
5310.468	011 - 000	4808 - 5963	734	1.476E-21	1.000E-27	4.920E-23	15
8341.32	031 - 000	8181 - 8656	102	1.627E-24	2.920E-27	6.130E-26	9
8779.75	111 - 000	8472 - 9192	335	9.856E-23	2.950E-27	3.360E-24	11
8966.53	012 - 000	8722 - 9291	155	2.873E-24	2.950E-27	7.880E-26	10
10298.	121 - 000	9412 - 10545	141	3.970E-24	2.980E-27	1.400E-25	10
10581.	201 - 000	10285 - 10905	279	4.202E-23	2.900E-27	1.430E-24	11
10990.	003 - 000	10761 - 11164	147	4.560E-24	2.980E-27	1.610E-25	10
14300.	301 - 000	13608 - 13901	49	1.811E-24	2.790E-27	1.204E-25	7
	-	13669 - 13670	2	4.260E-26	1.330E-26	2.930E-26	
Total Number of lines for the $H_2{}^{17}O$ (171) isotope is: 3,744							
	000 - 000	6 - 906	622	1.943E-20	1.000E-26	9.830E-22	17
	010 - 010	21 - 449	117	7.921E-24	1.000E-26	4.230E-25	11
1553.653	020 - 010	1270 - 1996	210	3.542E-24	1.510E-27	1.040E-25	10
1591.325	010 - 000	951 - 2249	872	3.978E-21	1.490E-27	1.120E-22	16
3144.978	020 - 000	2887 - 3994	247	2.409E-23	1.000E-26	5.490E-25	11
3653.143	100 - 000	3223 - 4127	387	1.699E-22	1.020E-26	9.370E-24	13
3728.937	011 - 010	3591 - 3858	34	6.618E-25	1.000E-26	3.630E-26	6
3748.318	001 - 000	3227 - 4243	529	2.516E-21	1.000E-26	7.890E-23	15
5320.262	011 - 000	5505 - 5840	86	9.627E-24	3.100E-27	9.490E-25	10
8356.70	031 - 000	8240 - 8533	35	1.913E-25	2.890E-27	1.170E-26	6
8792.63	111 - 000	8538 - 9072	226	1.807E-23	2.930E-27	6.220E-25	11
8983.	012 - 000	8808 - 9241	58	3.803E-25	2.860E-27	1.480E-26	8
10314.	121 - 000	10158 - 10505	70	6.361E-25	2.900E-27	2.630E-26	7
10597.	201 - 000	10344 - 10823	175	7.641E-24	2.890E-27	2.660E-25	10
11011.	003 - 000	10855 - 11151	76	7.311E-25	2.930E-27	2.920E-26	8
Total Number of lines for the $HD^{16}O$ (162) isotope is: 8,305							
	000 - 000	0 - 101	461	2.585E-21	1.240E-32	1.270E-22	17
1403.489	010 - 000	1104 - 1895	1653	2.816E-21	1.001E-27	2.668E-23	17
2723.6799	100 - 000	2332 - 3133	1333	6.337E-22	1.010E-27	9.750E-24	17
2782.0117	020 - 000	2486 - 3362	953	8.468E-23	1.000E-27	1.230E-24	15
3707.459	001 - 000	3236 - 4122	1651	1.416E-21	1.010E-27	1.750E-23	17
4099.954	110 - 000	3843 - 4497	860	6.426E-23	1.000E-27	9.360E-25	15
4145.483	030 - 000	3879 - 4640	602	3.504E-23	1.010E-27	8.760E-25	14
5089.539	011 - 000	4850 - 5385	576	3.671E-23	3.010E-27	5.530E-25	14
5372.114	200 - 000	5154 - 5508	216	1.589E-23	3.070E-27	2.940E-25	13
Total Number of lines for the $^{12}C^{16}O_2$ (626) isotope is: 27,107							
471.5112	20003 - 11101	442 - 504	61	1.000E-24	3.705E-27	3.854E-26	44
479.8980	13302 - 12201	479 - 482	28	5.223E-26	1.031E-27	2.388E-27	32
508.1663	12202 - 11101	474 - 550	139	5.570E-24	3.748E-27	1.032E-25	50
510.3208	21103 - 20002	488 - 538	46	3.844E-25	3.770E-27	1.613E-26	38
542.2202	21102 - 20001	514 - 571	55	7.037E-25	3.942E-27	2.807E-26	42
544.2858	11102 - 10001	493 - 602	107	3.158E-22	4.131E-27	1.174E-23	74
557.7860	14402 - 05501	544 - 558	29	1.264E-25	3.719E-27	4.865E-27	25
568.9082	13302 - 04401	531 - 607	137	7.128E-24	3.880E-27	1.344E-25	52
578.6313	21102 - 12201	543 - 614	132	3.789E-24	3.730E-27	7.216E-26	48
581.3891	22203 - 13302	555 - 608	93	9.008E-25	3.707E-27	1.866E-26	39
581.7760	12202 - 03301	530 - 632	189	1.968E-22	3.958E-27	3.699E-24	67

[*continued . . .*]

Table 2—*continued*

ν_o	$\nu' - \nu''$	$\nu_{min} - \nu_{max}$	#lines	ΣS	S_{min}	S_{max}	J''_{max}
594.2873	20002 - 11101	541 - 642	98	9.308E-23	3.956E-27	3.497E-24	66
596.4419	21103 - 12202	553 - 642	163	2.573E-23	4.107E-27	4.894E-25	58
597.3385	11102 - 02201	532 - 658	230	5.213E-21	4.041E-27	9.777E-23	79
603.1872	30003 - 21102	578 - 630	49	4.631E-25	3.776E-27	1.919E-26	38
608.8285	10012 - 01111	576 - 644	67	1.775E-24	4.084E-27	6.729E-26	47
611.2204	30004 - 21103	577 - 651	71	2.435E-24	3.709E-27	9.148E-26	48
615.8969	20003 - 11102	561 - 675	110	6.985E-22	4.559E-27	2.605E-23	74
618.0283	10002 - 01101	546 - 687	136	1.461E-19	4.483E-27	5.459E-21	91
633.0969	21103 - 20003	586 - 684	95	6.367E-23	3.709E-27	2.368E-24	64
634.8641	11112 - 10012	618 - 657	32	1.940E-25	3.784E-27	9.925E-27	33
640.5478	22203 - 21103	607 - 680	132	4.212E-24	3.837E-27	7.965E-26	49
645.1047	23303 - 22203	645 - 646	15	6.434E-26	3.715E-27	4.617E-27	24
647.0618	11102 - 10002	585 - 716	126	2.172E-20	5.365E-27	8.062E-22	84
652.5520	12202 - 11102	599 - 717	216	1.581E-21	4.206E-27	2.925E-23	75
654.8694	01111 - 00011	607 - 708	98	8.714E-23	4.194E-27	3.221E-24	67
655.2600	02211 - 01111	621 - 696	144	7.122E-24	3.955E-27	1.318E-25	52
655.6006	13302 - 12202	611 - 708	179	9.265E-23	4.156E-27	1.688E-24	64
655.6414	03311 - 02211	655 - 678	51	2.968E-25	3.881E-27	7.967E-27	31
657.6911	14402 - 13302	625 - 697	129	4.800E-24	3.834E-27	8.705E-26	49
659.2815	15502 - 14402	659 - 675	26	1.058E-25	3.722E-27	4.255E-27	22
667.3799	01101 - 00001	593 - 752	153	8.024E-18	5.167E-27	2.982E-19	102
667.7516	02201 - 01101	600 - 750	275	6.086E-19	4.843E-27	1.122E-20	94
668.1145	03301 - 02201	608 - 741	247	3.530E-20	3.806E-27	6.429E-22	86
668.2129	21102 - 20002	624 - 718	91	2.863E-23	3.817E-27	1.064E-24	62
668.4684	04401 - 03301	615 - 732	214	1.827E-21	3.775E-27	3.268E-23	76
668.5585	22202 - 21102	640 - 704	116	1.823E-24	3.712E-27	3.470E-26	43
668.8132	05501 - 04401	624 - 721	173	8.709E-23	3.865E-27	1.548E-24	64
669.1487	06601 - 05501	638 - 709	119	3.896E-24	3.752E-27	8.224E-26	48
669.4795	07701 - 06601	675 - 683	10	4.030E-26	3.702E-27	4.279E-27	15
675.8466	11111 - 10011	675 - 677	11	5.736E-26	4.049E-27	6.017E-27	27
680.0533	14401 - 13301	653 - 715	107	1.795E-24	3.760E-27	3.345E-26	43
681.4906	13301 - 12201	639 - 731	169	4.054E-23	3.772E-27	7.361E-25	60
683.8689	12201 - 11101	630 - 746	212	8.173E-22	3.763E-27	1.490E-23	73
688.6716	11101 - 10001	625 - 756	126	1.402E-20	4.030E-27	5.210E-22	84
696.6890	22201 - 21101	673 - 727	96	9.009E-25	3.797E-27	1.805E-26	39
703.5362	21101 - 20001	658 - 749	88	2.046E-23	3.832E-27	7.657E-25	60
710.7696	10011 - 01111	677 - 745	67	1.671E-24	3.803E-27	6.329E-26	47
720.2800	20001 - 11101	669 - 777	105	3.981E-22	4.999E-27	1.512E-23	72
720.8043	10001 - 01101	649 - 791	137	1.564E-19	4.663E-27	5.850E-21	92
724.4244	30001 - 21101	699 - 752	51	5.439E-25	3.832E-27	2.249E-26	40
724.9188	30002 - 21102	697 - 753	54	6.314E-25	3.742E-27	2.532E-26	40
738.6730	20002 - 11102	681 - 788	105	2.445E-22	3.712E-27	9.158E-24	72
739.9474	21101 - 12201	698 - 783	156	1.317E-23	3.717E-27	2.447E-25	55
741.7243	11101 - 02201	675 - 802	233	6.192E-21	4.176E-27	1.161E-22	81
754.3339	21102 - 12202	710 - 794	152	1.147E-23	3.916E-27	2.162E-25	54
755.1458	22201 - 13301	735 - 756	49	2.921E-25	3.834E-27	8.535E-27	32
757.4786	12201 - 03301	704 - 807	192	2.337E-22	3.806E-27	4.379E-24	68
761.0793	30003 - 21103	737 - 785	45	3.682E-25	3.864E-27	1.578E-26	36
767.2917	22202 - 13302	746 - 784	58	3.544E-25	3.707E-27	9.339E-27	33
770.5008	13301 - 04401	730 - 808	141	8.815E-24	3.964E-27	1.650E-25	53
781.7408	14401 - 05501	764 - 782	38	1.993E-25	3.876E-27	6.157E-27	28
790.9889	21102 - 20003	753 - 827	74	3.479E-24	3.715E-27	1.303E-25	52
791.4476	11101 - 10002	737 - 849	109	7.317E-22	3.769E-27	2.743E-23	74
828.2546	12201 - 11102	788 - 873	156	1.475E-23	3.716E-27	2.743E-25	55

[*continued...*]

Table 2—*continued*

ν_o	$V' - V''$	$\nu_{min} - \nu_{max}$	#lines	ΣS	S_{min}	S_{max}	J''_{max}
829.5290	21101 - 20002	805 - 860	52	5.735E-25	3.741E-27	2.326E-26	40
857.1932	13301 - 12202	857 - 881	56	3.667E-25	3.708E-27	9.453E-27	33
864.6658	20001 - 11102	827 - 904	75	4.090E-24	3.854E-27	1.541E-25	52
898.5476	02211 - 12201	860 - 927	84	1.346E-24	3.775E-27	2.667E-26	42
915.6500	21101 - 12202	914 - 916	16	1.914E-26	1.036E-27	1.298E-27	24
917.6461	10011 - 20001	876 - 945	44	9.427E-25	3.706E-27	3.679E-26	44
927.1564	01111 - 11101	868 - 964	138	4.065E-23	3.869E-27	7.807E-25	60
941.6976	10012 - 20002	901 - 974	47	1.340E-24	3.819E-27	5.175E-26	46
960.9586	00011 - 10001	886 - 1002	75	5.990E-22	3.824E-27	2.291E-23	74
1043.639	10011 - 20002	1002 - 1075	47	1.552E-24	4.639E-27	6.027E-26	46
1063.735	00011 - 10002	986 - 1105	77	9.215E-22	4.328E-27	3.568E-23	76
1064.474	10012 - 20003	1016 - 1095	51	3.172E-24	5.023E-27	1.221E-25	50
1066.241	11112 - 21103	1042 - 1086	41	2.051E-25	3.734E-27	5.875E-27	27
1071.542	01111 - 11102	1010 - 1109	149	7.484E-23	3.711E-27	1.453E-24	63
1074.250	02211 - 12202	1030 - 1105	99	2.954E-24	3.805E-27	5.764E-26	47
1846.332	21103 - 02201	1807 - 1882	69	7.229E-25	3.722E-27	2.069E-26	49
1880.987	20003 - 01101	1828 - 1936	88	1.271E-23	4.014E-27	5.962E-25	69
1896.056	21103 - 10002	1852 - 1941	69	2.062E-24	3.733E-27	1.000E-25	58
1905.491	13302 - 02201	1866 - 1946	113	1.788E-24	3.723E-27	4.209E-26	54
1917.642	12202 - 01101	1867 - 1975	186	3.856E-23	3.757E-27	8.734E-25	69
1932.470	11102 - 00001	1871 - 1999	118	6.583E-22	4.299E-27	2.957E-23	82
1951.172	21102 - 10001	1910 - 1959	50	1.075E-24	4.037E-27	4.802E-26	52
2003.246	03301 - 00001	1955 - 2074	87	2.258E-25	1.060E-28	1.080E-26	78
2003.763	20002 - 01101	1952 - 2039	66	3.046E-24	3.744E-27	1.537E-25	61
2004.224	21102 - 02201	1979 - 2005	29	1.294E-25	3.806E-27	5.189E-27	30
2053.948	21102 - 10002	2002 - 2098	84	1.137E-23	3.811E-27	4.576E-25	64
2075.444	22202 - 11102	2037 - 2085	90	1.167E-24	3.862E-27	2.376E-26	48
2076.856	11101 - 00001	2010 - 2145	127	5.378E-21	4.465E-27	2.110E-22	88
2093.345	12201 - 01101	2034 - 2156	219	5.078E-22	3.940E-27	9.734E-24	79
2107.084	13301 - 02201	2057 - 2157	174	3.400E-23	3.886E-27	6.393E-25	67
2112.488	21101 - 10001	2060 - 2161	92	2.316E-23	3.808E-27	9.388E-25	68
2119.022	14401 - 03301	2079 - 2131	98	1.940E-24	3.827E-27	3.808E-26	52
2120.505	22201 - 11101	2082 - 2128	94	1.543E-24	3.717E-27	3.414E-26	51
2129.756	20001 - 01101	2071 - 2189	110	3.074E-22	4.258E-27	1.283E-23	77
2131.805	30002 - 11102	2091 - 2132	43	6.798E-25	4.227E-27	3.091E-26	49
2148.241	30001 - 11101	2108 - 2149	47	1.156E-24	4.003E-27	5.396E-26	53
2165.541	21101 - 02201	2110 - 2210	160	1.628E-23	3.878E-27	3.776E-25	64
2170.849	11112 - 11101	2126 - 2203	100	4.184E-24	3.720E-27	8.206E-26	49
2180.699	20012 - 20001	2161 - 2197	13	5.537E-26	3.796E-27	4.640E-27	22
2182.480	20013 - 20002	2154 - 2208	32	2.485E-25	3.746E-27	1.085E-26	34
2194.115	22201 - 03301	2154 - 2195	69	7.844E-25	3.762E-27	2.255E-26	48
2215.264	21101 - 10002	2165 - 2262	83	6.567E-24	4.052E-27	3.067E-25	64
2224.656	10012 - 10001	2158 - 2265	69	1.178E-22	3.773E-27	4.576E-24	68
2274.422	06611 - 06601	2244 - 2299	62	4.568E-25	3.762E-27	1.167E-26	34
2275.842	14411 - 14401	2251 - 2297	42	2.152E-25	3.714E-27	6.144E-27	28
2277.173	22211 - 22201	2259 - 2294	23	9.363E-26	3.768E-27	4.378E-27	22
2277.984	30011 - 30001	2288 - 2292	3	1.145E-26	3.771E-27	3.853E-27	18
2278.387	14412 - 14402	2243 - 2306	77	8.896E-25	3.706E-27	1.823E-26	39
2280.618	22212 - 22202	2250 - 2305	61	4.917E-25	3.879E-27	1.107E-26	34
2281.674	22213 - 22203	2243 - 2310	85	1.383E-24	3.703E-27	2.786E-26	42
2283.296	30014 - 30004	2245 - 2312	42	8.133E-25	4.288E-27	3.241E-26	42
2283.577	30012 - 30002	2257 - 2305	27	1.753E-25	3.944E-27	8.329E-27	30
2285.374	30013 - 30003	2253 - 2311	35	3.623E-25	4.291E-27	1.518E-26	36
2286.799	03321 - 03311	2265 - 2305	33	1.490E-25	3.715E-27	5.101E-27	25

[*continued*. . .]

Table 2—*continued*

ν_o	$v' - v''$	$\nu_{min} - \nu_{max}$	#lines	ΣS	S_{min}	S_{max}	J''_{max}
2286.804	05511 - 05501	2234 - 2322	133	1.467E-23	3.733E-27	2.739E-25	56
2288.390	13311 - 13301	2238 - 2322	123	9.039E-24	3.955E-27	1.733E-25	53
2289.904	21111 - 21101	2242 - 2323	107	6.801E-24	3.737E-27	1.323E-25	51
2290.254	11122 - 11112	2265 - 2312	50	2.892E-25	3.810E-27	7.210E-27	30
2290.680	13312 - 13302	2235 - 2327	140	2.456E-23	4.014E-27	4.690E-25	58
2293.409	21112 - 21102	2241 - 2328	121	1.499E-23	3.806E-27	2.899E-25	56
2293.610	21113 - 21103	2237 - 2330	134	3.305E-23	4.035E-27	6.408E-25	59
2299.214	04411 - 04401	2230 - 2340	180	3.908E-22	3.739E-27	7.362E-24	70
2299.240	02221 - 02211	2251 - 2332	113	6.566E-24	4.144E-27	1.267E-25	51
2301.053	12211 - 12201	2234 - 2341	172	2.550E-22	4.260E-27	4.892E-24	68
2301.908	10021 - 10011	2256 - 2333	50	2.499E-24	4.617E-27	9.661E-26	49
2302.371	10022 - 10012	2253 - 2336	54	4.152E-24	3.789E-27	1.599E-25	53
2302.525	20011 - 20001	2235 - 2342	69	1.069E-22	3.729E-27	4.120E-24	68
2302.963	12212 - 12202	2231 - 2345	185	6.073E-22	3.766E-27	1.170E-23	72
2305.256	20013 - 20003	2234 - 2347	73	3.630E-22	4.589E-27	1.400E-23	72
2306.692	20012 - 20002	2237 - 2347	71	1.961E-22	4.253E-27	7.549E-24	70
2311.667	03311 - 03301	2227 - 2356	218	1.026E-20	3.817E-27	1.954E-22	82
2311.701	01121 - 01111	2246 - 2350	162	1.626E-22	3.819E-27	3.117E-24	67
2313.773	11111 - 11101	2231 - 2357	211	7.201E-21	3.774E-27	1.386E-22	81
2315.235	11112 - 11102	2230 - 2360	218	1.461E-20	4.129E-27	2.812E-22	83
2324.141	02211 - 02201	2227 - 2371	250	2.601E-19	4.004E-27	4.985E-21	92
2324.183	00021 - 00011	2244 - 2366	80	1.995E-21	4.118E-27	7.647E-23	79
2326.598	10011 - 10001	2231 - 2372	91	1.021E-19	6.392E-27	3.929E-21	90
2327.433	10012 - 10002	2231 - 2374	93	1.716E-19	5.452E-27	6.621E-21	92
2336.632	01111 - 01101	2227 - 2384	278	7.011E-18	3.908E-27	1.344E-19	101
2349.143	00011 - 00001	2230 - 2397	109	9.157E-17	8.059E-27	3.526E-18	108
2429.374	10011 - 10002	2364 - 2467	66	6.498E-23	3.994E-27	2.497E-24	66
2429.468	20012 - 20003	2408 - 2448	18	8.330E-26	3.720E-27	5.291E-27	26
2458.158	11111 - 11102	2417 - 2485	85	1.523E-24	3.705E-27	3.082E-26	44
3125.304	30004 - 01101	3087 - 3169	42	6.487E-25	3.831E-27	2.923E-26	51
3154.632	22203 - 01101	3123 - 3197	66	5.891E-25	3.761E-27	1.578E-26	47
3181.464	21103 - 00001	3131 - 3239	83	1.188E-23	3.750E-27	5.088E-25	68
3275.163	30003 - 01101	3232 - 3317	66	1.931E-24	3.730E-27	9.552E-26	57
3305.708	31103 - 10002	3270 - 3344	36	4.656E-25	3.911E-27	2.749E-26	50
3339.356	21102 - 00001	3279 - 3398	105	1.022E-22	3.717E-27	4.993E-24	76
3340.534	22202 - 01101	3294 - 3394	146	8.263E-24	3.759E-27	2.040E-25	63
3341.659	23302 - 02201	3310 - 3380	60	4.670E-25	3.774E-27	1.326E-26	46
3365.269	31102 - 10001	3331 - 3403	33	3.252E-25	4.131E-27	1.855E-26	48
3396.895	30002 - 01101	3346 - 3444	70	4.527E-24	4.209E-27	2.004E-25	63
3398.219	21113 - 11101	3371 - 3421	54	3.454E-25	3.762E-27	8.248E-27	31
3465.439	20013 - 10001	3410 - 3505	61	1.761E-23	4.208E-27	6.730E-25	60
3496.141	23313 - 13302	3468 - 3520	57	3.979E-25	3.851E-27	9.331E-27	33
3500.672	21101 - 00001	3444 - 3561	103	6.820E-23	4.020E-27	3.314E-24	74
3504.987	14412 - 04401	3461 - 3537	109	3.949E-24	3.750E-27	7.502E-26	48
3506.713	31114 - 21103	3473 - 3534	73	8.324E-25	3.913E-27	1.719E-26	38
3518.664	22213 - 12202	3468 - 3555	126	1.194E-23	3.741E-27	2.294E-25	55
3524.200	31113 - 21102	3499 - 3546	50	2.922E-25	3.854E-27	7.303E-27	30
3527.613	30014 - 20003	3476 - 3565	57	9.076E-24	4.774E-27	3.485E-25	56
3527.808	22212 - 12201	3484 - 3559	100	3.149E-24	3.792E-27	6.148E-26	47
3528.057	13312 - 03301	3465 - 3568	163	1.076E-22	4.026E-27	2.043E-24	65
3529.981	22201 - 01101	3486 - 3579	140	5.028E-24	3.837E-27	1.231E-25	58
3533.947	11122 - 01111	3496 - 3564	86	1.599E-24	3.911E-27	3.158E-26	43
3542.604	21113 - 11102	3476 - 3584	85	1.472E-22	4.220E-27	5.580E-24	69
3543.095	40002 - 11102	3502 - 3583	58	9.824E-24	4.380E-27	4.810E-25	51

[*continued*. . .]

Table 2—*continued*

ν_o	$v' - v''$	ν_{min} - ν_{max}	#lines	ΣS	S_{min}	S_{max}	J''_{max}
3550.716	30012 - 20001	3506 - 3579	47	1.649E-24	4.830E-27	6.437E-26	46
3552.854	12212 - 02201	3475 - 3598	204	2.871E-21	3.898E-27	5.513E-23	78
3555.909	21112 - 11101	3492 - 3593	153	9.711E-23	3.778E-27	1.866E-24	65
3556.774	30013 - 20002	3506 - 3591	55	5.428E-24	4.263E-27	2.080E-25	54
3557.717	30001 - 01101	3508 - 3622	76	1.732E-23	4.417E-27	1.123E-24	75
3566.069	10022 - 00011	3509 - 3604	62	2.023E-23	4.234E-27	7.676E-25	61
3568.215	20013 - 10002	3490 - 3615	81	3.118E-21	5.217E-27	1.192E-22	80
3580.325	11112 - 01101	3488 - 3628	237	7.387E-20	3.858E-27	1.418E-21	89
3589.651	20012 - 10001	3506 - 3628	79	1.621E-21	4.386E-27	6.213E-23	78
3612.841	10012 - 00001	3509 - 3661	99	1.003E-18	5.015E-27	3.855E-20	98
3659.272	02211 - 00001	3584 - 3714	79	1.007E-22	4.400E-27	4.460E-24	84
3667.547	10021 - 00011	3606 - 3704	64	3.474E-23	3.897E-27	1.337E-24	63
3675.693	11121 - 01111	3633 - 3705	93	2.826E-24	4.197E-27	5.546E-26	46
3676.708	30012 - 20002	3626 - 3711	55	7.307E-24	5.183E-27	2.824E-25	54
3679.550	30013 - 20003	3622 - 3710	57	7.904E-24	3.878E-27	3.048E-25	56
3682.093	31113 - 21103	3648 - 3706	67	6.286E-25	3.753E-27	1.348E-26	36
3684.319	31112 - 21102	3654 - 3708	63	4.900E-25	3.737E-27	1.076E-26	34
3692.427	20012 - 10002	3606 - 3731	81	3.622E-21	4.744E-27	1.394E-22	80
3700.295	21112 - 11102	3629 - 3738	170	2.901E-22	3.848E-27	5.591E-24	69
3703.157	31111 - 21101	3680 - 3723	43	2.188E-25	3.718E-27	6.040E-27	27
3703.510	22212 - 12202	3651 - 3736	124	1.171E-23	3.989E-27	2.257E-25	54
3704.112	23312 - 13302	3675 - 3727	56	3.819E-25	3.851E-27	9.031E-27	32
3705.945	30011 - 20001	3658 - 3740	53	4.319E-24	4.400E-27	1.672E-25	52
3711.476	20011 - 10001	3635 - 3757	79	2.936E-21	6.518E-27	1.133E-22	78
3712.412	23311 - 13301	3689 - 3733	42	2.140E-25	3.708E-27	6.099E-27	28
3713.720	21111 - 11101	3648 - 3755	166	2.272E-22	3.706E-27	4.379E-24	68
3713.809	22211 - 12201	3665 - 3747	118	8.467E-24	3.722E-27	1.636E-25	52
3714.782	10011 - 00001	3610 - 3763	99	1.504E-18	4.678E-27	5.846E-20	98
3723.249	11111 - 01101	3629 - 3770	239	1.180E-19	4.189E-27	2.293E-21	89
3724.133	15511 - 05501	3702 - 3743	33	1.476E-25	3.757E-27	5.010E-27	25
3726.396	14411 - 04401	3678 - 3759	119	7.065E-24	3.882E-27	1.341E-25	51
3726.646	12211 - 02201	3646 - 3770	209	4.721E-21	3.748E-27	9.052E-23	79
3727.359	13311 - 03301	3661 - 3767	170	1.844E-22	3.887E-27	3.511E-24	67
3799.484	30012 - 20003	3772 - 3820	27	1.706E-25	3.838E-27	8.017E-27	30
3814.252	20011 - 10002	3753 - 3854	65	6.079E-23	4.528E-27	2.348E-24	64
3858.106	21111 - 11102	3818 - 3887	87	1.895E-24	3.702E-27	3.765E-26	44
3980.582	01121 - 02201	3975 - 4003	59	5.804E-25	3.866E-27	1.828E-26	47
4005.946	00021 - 01101	3934 - 4029	86	8.791E-24	3.702E-27	4.242E-25	65
4416.149	31104 - 00001	4426 - 4452	16	1.083E-25	3.958E-27	8.722E-27	42
4591.117	31103 - 00001	4546 - 4638	68	2.255E-24	3.784E-27	1.129E-25	60
4687.796	30014 - 10001	4652 - 4719	42	7.357E-25	4.185E-27	2.884E-26	42
4722.649	32214 - 12202	4705 - 4740	23	9.272E-26	3.726E-27	4.333E-27	22
4733.518	23313 - 03301	4696 - 4763	87	1.375E-24	3.850E-27	2.741E-26	42
4735.611	40015 - 20003	4712 - 4757	24	1.366E-25	3.785E-27	6.962E-27	28
4753.454	31102 - 00001	4706 - 4800	72	2.798E-24	3.739E-27	1.377E-25	60
4755.707	31114 - 11102	4712 - 4792	102	4.626E-24	3.707E-27	8.936E-26	50
4768.554	22213 - 02201	4711 - 4807	144	3.448E-23	3.902E-27	6.578E-25	60
4784.681	20023 - 00011	4762 - 4805	21	1.084E-25	3.964E-27	6.051E-27	27
4786.701	31113 - 11101	4750 - 4814	78	1.105E-24	3.713E-27	2.247E-26	41
4790.572	30014 - 10002	4733 - 4834	65	4.175E-23	4.380E-27	1.592E-24	64
4807.694	21113 - 01101	4736 - 4854	183	6.643E-22	3.780E-27	1.310E-23	73
4808.185	40002 - 01101	4764 - 4851	65	2.205E-23	4.320E-27	1.070E-24	55
4839.733	30013 - 10001	4780 - 4874	61	1.654E-23	4.143E-27	6.300E-25	60
4853.624	20013 - 00001	4772 - 4903	85	8.046E-21	4.136E-27	3.141E-22	84

[*continued . . .*]

Table 2—*continued*

ν_o	v' - v"	ν_{min} - ν_{max}	#lines	ΣS	S_{min}	S_{max}	J''_{max}
4887.985	12212 - 00001	4827 - 4937	61	4.586E-24	4.100E-27	1.830E-25	70
4910.605	20022 - 00011	4872 - 4937	41	7.308E-25	4.633E-27	2.898E-26	41
4912.160	40014 - 20003	4879 - 4936	35	3.336E-25	4.018E-27	1.391E-26	36
4920.211	32213 - 12202	4893 - 4942	49	2.889E-25	3.748E-27	7.337E-27	30
4922.552	40013 - 20002	4889 - 4946	35	3.284E-25	3.894E-27	1.373E-26	36
4931.086	31113 - 11102	4879 - 4964	114	9.866E-24	3.733E-27	1.909E-25	54
4937.312	40012 - 20001	4922 - 4953	8	3.179E-26	3.838E-27	4.163E-27	20
4941.488	23312 - 03301	4897 - 4972	103	2.995E-24	3.778E-27	5.810E-26	47
4942.509	30013 - 10002	4872 - 4978	69	1.288E-22	4.853E-27	4.928E-24	68
4946.819	31112 - 11101	4900 - 4979	102	4.962E-24	3.720E-27	9.668E-26	50
4953.401	22212 - 02201	4890 - 4991	158	8.421E-23	3.827E-27	1.612E-24	64
4959.667	30012 - 10001	4892 - 4996	67	7.944E-23	4.283E-27	3.064E-24	66
4965.385	21112 - 01101	4884 - 5007	198	2.342E-21	3.852E-27	4.499E-23	77
4977.835	20012 - 00001	4881 - 5018	89	3.457E-20	3.947E-27	1.333E-21	88
5028.481	20021 - 00011	5000 - 5052	31	2.288E-25	3.826E-27	1.011E-26	33
5061.778	12211 - 00001	4999 - 5109	61	5.211E-24	4.670E-27	2.080E-25	70
5062.443	30012 - 10002	5002 - 5096	61	2.458E-23	4.673E-27	9.526E-25	60
5091.205	31112 - 11102	5050 - 5120	89	2.212E-24	3.701E-27	4.399E-26	45
5099.661	20011 - 00001	5017 - 5148	85	1.090E-20	4.636E-27	4.204E-22	84
5114.896	30011 - 10001	5060 - 5155	61	2.859E-23	5.418E-27	1.107E-24	60
5123.196	21111 - 01101	5050 - 5167	185	9.886E-22	4.126E-27	1.914E-23	73
5126.973	31111 - 11101	5086 - 5158	91	2.509E-24	4.107E-27	4.973E-26	45
5139.402	22211 - 02201	5081 - 5176	145	4.089E-23	3.950E-27	7.868E-25	60
5151.381	23311 - 03301	5112 - 5181	90	1.601E-24	3.739E-27	3.186E-26	43
5217.672	30011 - 10002	5176 - 5250	47	1.967E-24	4.935E-27	7.741E-26	46
5247.833	10022 - 01101	5226 - 5271	55	8.920E-25	3.948E-27	3.154E-26	47
5291.132	02221 - 01101	5260 - 5313	101	1.103E-24	3.771E-27	2.239E-26	40
5315.713	01121 - 00001	5257 - 5342	87	1.696E-23	3.742E-27	6.272E-25	60
5584.393	00031 - 10001	5538 - 5601	40	5.990E-25	4.147E-27	2.412E-26	40
5687.169	00031 - 10002	5638 - 5703	42	6.740E-25	3.784E-27	2.659E-26	42
5972.540	32214 - 02201	5949 - 5995	46	2.450E-25	3.722E-27	6.461E-27	29
5998.570	40015 - 10002	5967 - 6028	37	3.906E-25	3.795E-27	1.588E-26	38
6020.797	31114 - 01101	5975 - 6059	108	6.728E-24	3.955E-27	1.289E-25	52
6075.980	30014 - 00001	6019 - 6121	66	5.303E-23	4.510E-27	2.121E-24	66
6149.365	41114 - 11102	6160 - 6164	5	1.881E-26	3.711E-27	3.788E-27	18
6170.102	32213 - 02201	6132 - 6198	82	1.169E-24	3.735E-27	2.359E-26	41
6175.119	40014 - 10002	6130 - 6207	50	2.244E-24	3.728E-27	8.612E-26	50
6196.176	31113 - 01101	6137 - 6233	136	3.311E-23	3.778E-27	6.359E-25	60
6205.511	40013 - 10001	6160 - 6232	47	1.419E-24	4.157E-27	5.533E-26	46
6227.917	30013 - 00001	6150 - 6266	75	4.737E-22	4.634E-27	1.839E-23	74
6308.287	40013 - 10002	6260 - 6335	49	2.012E-24	4.178E-27	7.818E-26	48
6346.264	40012 - 10001	6303 - 6376	47	1.282E-24	3.740E-27	5.012E-26	46
6347.852	30012 - 00001	6271 - 6386	75	4.738E-22	4.454E-27	1.846E-23	74
6356.295	31112 - 01101	6297 - 6392	134	3.354E-23	4.135E-27	6.480E-25	59
6359.257	32212 - 02201	6322 - 6386	80	1.179E-24	3.954E-27	2.403E-26	40
6387.868	41101 - 00001	6355 - 6424	30	2.130E-25	4.040E-27	9.980E-27	44
6503.081	30011 - 00001	6443 - 6547	67	6.119E-23	3.978E-27	2.399E-24	66
6532.654	40011 - 10001	6506 - 6557	29	1.996E-25	3.735E-27	9.142E-27	32
6536.449	31111 - 01101	6489 - 6572	107	7.003E-24	3.927E-27	1.378E-25	51
6537.959	11122 - 00001	6516 - 6561	50	5.674E-25	3.789E-27	2.233E-26	40
6562.441	32211 - 02201	6547 - 6577	15	5.873E-26	3.740E-27	4.130E-27	19
6679.706	11121 - 00001	6651 - 6704	63	1.603E-24	3.916E-27	5.526E-26	50
6870.800	11132 - 11102	6848 - 6885	30	1.291E-25	3.743E-27	4.747E-27	24
6897.752	02231 - 02201	6836 - 6915	109	5.154E-24	3.964E-27	9.978E-26	50

[*continued*. . .]

Table 2—*continued*

ν_o	v' - v"	ν_{min}- ν_{max}	#lines	ΣS	S_{min}	S_{max}	J''_{max}
6905.767	10031 - 10001	6850 - 6922	47	1.520E-24	4.567E-27	5.913E-26	46
6907.143	10032 - 10002	6846 - 6924	51	2.722E-24	4.137E-27	1.054E-25	50
6935.134	01131 - 01101	6844 - 6952	158	1.290E-22	3.761E-27	2.474E-24	66
6972.577	00031 - 00001	6856 - 6989	79	1.579E-21	3.936E-27	6.044E-23	78
7283.978	40015 - 00001	7253 - 7314	37	3.884E-25	3.899E-27	1.569E-26	38
7414.455	41114 - 01101	7386 - 7438	57	3.727E-25	3.717E-27	8.566E-27	32
7460.527	40014 - 00001	7409 - 7494	55	4.815E-24	4.074E-27	1.828E-25	54
7583.252	41113 - 01101	7550 - 7608	70	6.857E-25	3.719E-27	1.444E-26	37
7593.695	40013 - 00001	7535 - 7623	57	1.018E-23	5.078E-27	3.931E-25	56
7734.448	40012 - 00001	7687 - 7766	51	2.794E-24	4.113E-27	1.092E-25	50
7757.625	41112 - 01101	7740 - 7773	19	7.507E-26	3.701E-27	4.182E-27	21
7901.479	21122 - 00001	7898 - 7917	15	6.927E-26	3.820E-27	5.420E-27	24
7920.838	40011 - 00001	7899 - 7943	22	1.225E-25	4.148E-27	6.821E-27	28
8103.586	20033 - 10002	8080 - 8119	18	8.457E-26	3.762E-27	5.353E-27	26
8135.890	11132 - 01101	8079 - 8154	98	3.657E-24	3.967E-27	7.091E-26	48
8192.551	10032 - 00001	8107 - 8210	65	4.308E-23	3.917E-27	1.660E-24	64
8231.561	20032 - 10002	8207 - 8246	18	8.457E-26	3.761E-27	5.353E-27	26
8243.169	20031 - 10001	8224 - 8256	11	4.419E-26	3.778E-27	4.279E-27	20
8276.760	11131 - 01101	8216 - 8293	101	4.746E-24	3.983E-27	9.249E-26	49
8293.951	10031 - 00001	8206 - 8310	65	6.137E-23	5.579E-27	2.365E-24	64
9388.994	20033 - 00001	9350 - 9408	36	3.936E-25	3.783E-27	1.633E-26	38
9516.969	20032 - 00001	9454 - 9533	51	2.503E-24	3.780E-27	9.706E-26	50
9631.353	20031 - 00001	9583 - 9649	42	8.834E-25	4.710E-27	3.513E-26	42
Total Number of lines for the $^{13}C^{16}O_2$ (636) isotope is: 8,839							
526.4759	11102 - 10001	497 - 563	64	1.272E-24	3.816E-27	4.800E-26	46
573.6826	13302 - 04401	573 - 574	28	5.308E-26	1.017E-27	2.454E-27	33
585.3282	12202 - 03301	552 - 620	125	3.266E-24	3.831E-27	6.261E-26	47
595.6752	21103 - 12202	579 - 597	40	2.265E-25	3.793E-27	7.987E-27	31
599.2747	11102 - 02201	551 - 650	181	8.494E-23	3.923E-27	1.610E-24	64
607.9745	20002 - 11101	573 - 643	68	1.894E-24	3.748E-27	7.211E-26	48
610.9915	20003 - 11102	571 - 657	83	1.056E-23	4.139E-27	3.923E-25	56
617.3497	10002 - 01101	560 - 680	116	2.280E-21	5.003E-27	8.519E-23	78
619.8238	21103 - 20003	591 - 650	57	8.473E-25	4.240E-27	3.306E-26	42
630.7103	11102 - 10002	578 - 687	105	2.720E-22	3.753E-27	1.011E-23	70
635.1401	12202 - 11102	596 - 681	159	1.993E-23	4.118E-27	3.724E-25	57
636.7508	01111 - 00011	607 - 670	63	1.194E-24	4.067E-27	4.538E-26	45
637.7635	13302 - 12202	613 - 669	100	1.176E-24	3.727E-27	2.297E-26	41
644.6333	21102 - 20002	624 - 670	41	2.835E-25	3.765E-27	1.263E-26	36
648.4780	01101 - 00001	582 - 721	134	8.448E-20	3.915E-27	3.142E-21	90
648.7852	02201 - 01101	591 - 718	234	6.931E-21	3.707E-27	1.280E-22	81
649.0867	03301 - 02201	600 - 708	199	4.393E-22	4.139E-27	7.996E-24	70
649.4090	04401 - 03301	609 - 697	158	2.455E-23	3.750E-27	4.399E-25	58
649.6874	05501 - 04401	625 - 682	92	1.194E-24	3.707E-27	2.284E-26	41
661.1353	13301 - 12201	661 - 686	57	3.917E-25	3.878E-27	9.807E-27	33
663.1711	12201 - 11101	626 - 707	149	9.534E-24	3.982E-27	1.755E-25	53
667.0312	11101 - 10001	618 - 721	100	1.355E-22	4.875E-27	5.031E-24	68
683.1743	21101 - 20001	683 - 703	24	1.376E-25	3.721E-27	8.470E-27	32
713.5031	20001 - 11101	676 - 751	74	3.469E-24	3.708E-27	1.312E-25	52
721.5841	10001 - 01101	660 - 777	113	1.132E-21	4.264E-27	4.231E-23	76
733.5063	21101 - 12201	731 - 734	30	6.041E-26	1.056E-27	2.644E-27	33
739.8301	11101 - 02201	689 - 785	176	5.531E-23	3.939E-27	1.036E-24	62
748.5299	20002 - 11102	712 - 781	67	1.851E-24	3.903E-27	7.032E-26	48

[*continued*. . .]

Table 2—*continued*

ν_o	$\nu' - \nu''$	$\nu_{min} - \nu_{max}$	#lines	ΣS	S_{min}	S_{max}	J''_{max}
765.6407	13301 - 04401	764 - 766	24	3.952E-26	1.083E-27	1.995E-27	30
771.2656	11101 - 10002	726 - 814	85	1.283E-23	3.898E-27	4.773E-25	58
803.7264	12201 - 11102	803 - 818	28	1.358E-25	3.716E-27	5.960E-27	27
883.1446	01111 - 11101	853 - 908	63	5.127E-25	3.844E-27	1.106E-26	34
913.4250	00011 - 10001	862 - 950	57	7.900E-24	3.758E-27	3.088E-25	56
1017.659	00011 - 10002	965 - 1050	55	5.334E-24	3.704E-27	2.087E-25	54
1023.700	01111 - 11102	992 - 1048	64	5.319E-25	3.874E-27	1.161E-26	35
1883.200	12202 - 01101	1856 - 1873	23	1.195E-25	3.816E-27	6.034E-27	36
1896.538	11102 - 00001	1850 - 1944	79	4.092E-24	4.305E-27	1.905E-25	62
1996.590	20002 - 01101	1957 - 1997	38	4.140E-25	3.817E-27	2.036E-26	47
2023.873	21102 - 10002	1994 - 2015	13	7.188E-26	3.911E-27	6.620E-27	36
2037.093	11101 - 00001	1980 - 2089	100	6.277E-23	4.248E-27	2.548E-24	72
2051.786	12201 - 01101	2006 - 2091	137	6.266E-24	3.795E-27	1.277E-25	59
2063.708	21101 - 10001	2032 - 2066	33	2.775E-25	4.084E-27	1.152E-26	40
2064.136	13301 - 02201	2031 - 2072	72	5.618E-25	3.714E-27	1.118E-26	42
2102.118	20001 - 01101	2053 - 2140	71	3.425E-24	3.908E-27	1.526E-25	59
2136.508	21101 - 02201	2109 - 2137	33	1.503E-25	3.705E-27	5.502E-27	32
2157.675	10012 - 10001	2121 - 2188	42	7.645E-25	4.040E-27	3.052E-26	42
2167.943	21101 - 10002	2140 - 2157	11	5.209E-26	3.712E-27	5.383E-27	34
2225.024	05511 - 05501	2206 - 2243	24	9.856E-26	3.709E-27	4.449E-27	23
2227.810	13312 - 13302	2202 - 2249	44	2.427E-25	3.770E-27	6.564E-27	29
2229.651	21113 - 21103	2202 - 2253	56	3.667E-25	3.760E-27	8.601E-27	32
2230.223	21112 - 21102	2240 - 2244	6	2.264E-26	3.718E-27	3.813E-27	18
2236.678	04411 - 04401	2190 - 2270	116	5.744E-24	3.752E-27	1.094E-25	51
2238.570	12211 - 12201	2195 - 2270	101	3.434E-24	3.765E-27	6.715E-26	48
2239.297	12212 - 12202	2190 - 2273	117	8.013E-24	3.959E-27	1.552E-25	52
2240.536	20013 - 20003	2192 - 2274	53	4.552E-24	4.752E-27	1.765E-25	52
2240.757	20011 - 20001	2198 - 2271	47	1.343E-24	3.933E-27	5.243E-26	46
2242.323	20012 - 20002	2198 - 2274	49	2.269E-24	4.816E-27	8.822E-26	48
2248.356	03311 - 03301	2184 - 2288	166	1.398E-22	3.892E-27	2.662E-24	66
2248.361	01121 - 01111	2207 - 2279	92	2.450E-24	3.795E-27	4.811E-26	46
2250.605	11111 - 11101	2188 - 2289	152	8.939E-23	3.890E-27	1.721E-24	64
2250.694	11112 - 11102	2185 - 2291	163	1.801E-22	3.822E-27	3.484E-24	67
2260.049	02211 - 02201	2181 - 2304	205	3.333E-21	4.054E-27	6.390E-23	78
2260.061	00021 - 00011	2202 - 2297	62	2.809E-23	5.233E-27	1.078E-24	61
2261.910	10012 - 10002	2183 - 2306	79	1.946E-21	4.813E-27	7.502E-23	78
2262.848	10011 - 10001	2186 - 2305	77	1.162E-21	5.170E-27	4.470E-23	76
2271.760	01111 - 01101	2180 - 2318	235	7.686E-20	4.490E-27	1.479E-21	88
2283.487	00011 - 00001	2182 - 2331	98	9.285E-19	3.750E-27	3.577E-20	98
2367.083	10011 - 10002	2331 - 2392	37	4.272E-25	3.814E-27	1.723E-26	38
3289.701	21102 - 00001	3250 - 3332	44	8.305E-25	4.152E-27	4.275E-26	54
3450.902	13312 - 03301	3416 - 3479	77	9.510E-25	3.758E-27	1.933E-26	39
3460.466	21113 - 11102	3420 - 3492	90	2.268E-24	3.872E-27	4.497E-26	45
3473.712	12212 - 02201	3420 - 3512	139	2.462E-23	3.700E-27	4.713E-25	59
3482.238	20013 - 10002	3427 - 3522	61	2.198E-23	5.234E-27	8.417E-25	60
3482.693	10022 - 00011	3460 - 3503	21	1.070E-25	3.889E-27	5.980E-27	27
3482.831	21112 - 11101	3449 - 3510	73	8.241E-25	3.844E-27	1.713E-26	38
3497.289	30001 - 01101	3453 - 3540	63	5.263E-23	4.070E-27	5.190E-24	55
3498.754	11112 - 01101	3431 - 3544	131	7.271E-22	4.560E-27	1.410E-23	72
3517.329	20012 - 10001	3462 - 3553	59	1.301E-23	4.782E-27	4.968E-25	58
3527.738	10012 - 00001	3448 - 3576	83	5.737E-21	5.733E-27	2.186E-22	82
3589.064	10021 - 00011	3553 - 3615	39	5.543E-25	4.396E-27	2.236E-26	39
3621.291	20011 - 10001	3562 - 3659	63	4.092E-23	5.569E-27	1.578E-24	62
3621.563	20012 - 10002	3555 - 3656	65	4.196E-23	3.731E-27	1.615E-24	64

[*continued*...]

Table 2—*continued*

ν_o	$\nu' - \nu''$	$\nu_{min} - \nu_{max}$	#lines	ΣS	S_{min}	S_{max}	J''_{max}
3623.386	21112 - 11102	3577 - 3653	98	3.722E-24	3.862E-27	7.302E-26	48
3625.165	21111 - 11101	3581 - 3656	95	3.205E-24	3.985E-27	6.290E-26	47
3632.910	10011 - 00001	3541 - 3675	87	1.886E-20	3.937E-27	7.267E-22	86
3639.220	11111 - 01101	3561 - 3680	192	1.546E-21	3.749E-27	2.975E-23	75
3641.571	12211 - 02201	3580 - 3678	152	6.454E-23	4.108E-27	1.238E-24	62
3641.676	13311 - 03301	3598 - 3672	100	2.645E-24	3.858E-27	5.160E-26	46
3725.525	20011 - 10002	3685 - 3752	42	7.368E-25	3.938E-27	2.899E-26	42
4673.736	22213 - 02201	4655 - 4692	26	1.092E-25	3.759E-27	4.570E-27	23
4685.776	30014 - 10002	4659 - 4711	29	1.998E-25	3.961E-27	9.058E-27	32
4708.526	21113 - 01101	4665 - 4744	100	4.343E-24	3.897E-27	8.490E-26	49
4748.065	20013 - 00001	4693 - 4792	64	3.328E-23	3.773E-27	1.263E-24	64
4871.446	21112 - 01101	4815 - 4907	128	2.189E-23	3.845E-27	4.222E-25	58
4887.391	20012 - 00001	4813 - 4926	73	2.728E-22	3.897E-27	1.042E-23	72
4976.144	30012 - 10002	4941 - 4999	35	3.686E-25	4.284E-27	1.546E-26	36
4991.353	20011 - 00001	4923 - 5029	69	1.927E-22	5.687E-27	7.465E-24	68
4993.562	30011 - 10001	4960 - 5020	38	4.754E-25	3.914E-27	1.922E-26	38
5013.780	21111 - 01101	4959 - 5048	123	1.605E-23	3.703E-27	3.112E-25	56
5028.813	22211 - 02201	4997 - 5053	66	5.951E-25	3.791E-27	1.292E-26	35
5168.599	01121 - 00001	5165 - 5169	10	4.926E-26	3.952E-27	5.564E-27	26
5951.604	30014 - 00001	5929 - 5974	23	1.242E-25	3.990E-27	6.475E-27	28
6088.218	31113 - 01101	6071 - 6104	19	7.554E-26	3.745E-27	4.199E-27	21
6119.623	30013 - 00001	6075 - 6152	49	2.120E-24	4.481E-27	8.252E-26	48
6241.972	30012 - 00001	6187 - 6272	55	5.496E-24	3.967E-27	2.123E-25	54
6243.638	31112 - 01101	6217 - 6265	52	3.236E-25	3.803E-27	7.889E-27	31
6363.624	30011 - 00001	6323 - 6393	45	1.281E-24	4.212E-27	5.032E-26	44
6745.112	01131 - 01101	6697 - 6763	84	1.409E-24	3.753E-27	2.821E-26	42
6780.210	00031 - 00001	6705 - 6797	60	1.638E-23	3.703E-27	6.321E-25	60
7981.186	10032 - 00001	7948 - 7999	31	2.297E-25	3.770E-27	1.008E-26	34
8089.028	10031 - 00001	8039 - 8105	42	7.780E-25	4.158E-27	3.087E-26	42
Total Number of lines for the $^{16}O^{12}C^{18}O$ (628) isotope is: 13,314							
535.8935	11102 - 10001	507 - 567	121	1.834E-24	3.707E-27	3.477E-26	45
561.1210	12202 - 03301	547 - 562	68	3.348E-25	3.759E-27	6.323E-27	29
564.9089	20002 - 11101	563 - 565	21	1.019E-25	3.700E-27	5.518E-27	27
576.5960	11102 - 02201	537 - 615	302	1.772E-23	3.920E-27	1.629E-25	54
597.0518	10002 - 01101	544 - 647	210	4.372E-22	4.377E-27	7.974E-24	72
599.0230	20003 - 11102	568 - 632	130	2.475E-24	3.774E-27	4.622E-26	47
642.3118	11102 - 10002	598 - 692	192	9.115E-23	3.716E-27	1.648E-24	66
647.7121	12202 - 11102	617 - 685	266	6.946E-24	3.799E-27	6.351E-26	49
662.3734	01101 - 00001	602 - 731	260	3.201E-20	3.815E-27	5.777E-22	88
662.7676	02201 - 01101	611 - 724	444	2.548E-21	3.745E-27	2.273E-23	77
663.1870	03301 - 02201	621 - 714	364	1.500E-22	4.005E-27	1.327E-24	65
663.6030	04401 - 03301	633 - 701	254	7.688E-24	3.990E-27	6.829E-26	49
678.9024	12201 - 11101	651 - 713	240	3.708E-24	3.756E-27	3.416E-26	45
683.4954	11101 - 10001	639 - 731	186	6.501E-23	3.937E-27	1.178E-24	64
703.4701	10001 - 01101	651 - 758	218	7.975E-22	3.985E-27	1.457E-23	75
707.8388	20001 - 11101	680 - 739	120	1.912E-24	3.912E-27	3.680E-26	45
712.5108	20002 - 11102	685 - 741	114	1.399E-24	3.879E-27	2.700E-26	43
724.1978	11101 - 02201	682 - 765	322	3.032E-23	4.148E-27	2.747E-25	57
739.9134	12201 - 03301	718 - 759	140	8.996E-25	3.735E-27	1.049E-26	35
789.9136	11101 - 10002	762 - 822	120	1.854E-24	3.930E-27	3.534E-26	45
966.2689	00011 - 10001	927 - 994	88	1.731E-24	3.711E-27	3.373E-26	45
1072.687	00011 - 10002	1030 - 1103	99	3.539E-24	3.770E-27	6.767E-26	49

[*continued*. . .]

Table 2—*continued*

ν_o	$v' - v''$	$\nu_{min} - \nu_{max}$	#lines	ΣS	S_{min}	S_{max}	J''_{max}
1080.374	01111 - 11102	1065 - 1096	30	1.160E-25	3.707E-27	4.036E-27	21
1239.364	11102 - 01101	1209 - 1271	156	2.081E-24	3.860E-27	2.082E-26	41
1259.425	10002 - 00001	1214 - 1306	124	3.245E-23	3.771E-27	6.025E-25	62
1365.843	10001 - 00001	1322 - 1413	123	3.549E-23	4.272E-27	6.663E-25	61
1386.965	11101 - 01101	1354 - 1421	176	3.289E-24	3.768E-27	3.208E-26	44
1901.737	11102 - 00001	1860 - 1937	124	3.060E-24	3.767E-27	6.753E-26	57
2049.339	11101 - 00001	2003 - 2088	154	1.752E-23	3.733E-27	3.251E-25	65
2065.868	12201 - 01101	2033 - 2074	170	1.741E-24	3.789E-27	1.689E-26	46
2094.804	20001 - 01101	2061 - 2095	83	1.042E-24	3.833E-27	2.118E-26	47
2205.297	10012 - 10001	2177 - 2227	60	4.310E-25	3.728E-27	9.623E-27	34
2282.729	04411 - 04401	2250 - 2308	150	1.542E-24	3.804E-27	1.572E-26	39
2284.374	12211 - 12201	2255 - 2308	126	1.021E-24	3.907E-27	1.114E-26	35
2287.110	12212 - 12202	2251 - 2315	170	2.718E-24	3.856E-27	2.681E-26	43
2290.500	20013 - 20003	2252 - 2318	87	1.753E-24	4.091E-27	3.384E-26	44
2290.612	20012 - 20002	2256 - 2316	77	9.684E-25	3.911E-27	1.927E-26	40
2295.041	01121 - 01111	2271 - 2315	96	5.311E-25	3.812E-27	6.730E-27	30
2295.045	03311 - 03301	2241 - 2330	284	4.411E-23	3.873E-27	4.087E-25	59
2296.847	11111 - 11101	2244 - 2331	251	3.273E-23	3.712E-27	3.074E-25	58
2299.414	11112 - 11102	2244 - 2335	276	6.748E-23	4.008E-27	6.323E-25	61
2307.383	02211 - 02201	2238 - 2347	374	1.127E-21	4.351E-27	1.050E-23	73
2307.389	00021 - 00011	2259 - 2339	109	8.584E-24	4.234E-27	1.606E-25	54
2309.289	10011 - 10001	2240 - 2348	147	4.616E-22	3.803E-27	8.640E-24	73
2311.715	10012 - 10002	2241 - 2351	151	7.749E-22	3.904E-27	1.449E-23	75
2319.738	01111 - 01101	2236 - 2362	448	2.879E-20	3.710E-27	2.691E-22	85
2332.112	00011 - 00001	2235 - 2376	193	3.683E-19	3.720E-27	6.848E-21	96
2415.708	10011 - 10002	2393 - 2436	45	2.294E-25	3.708E-27	6.104E-27	29
2464.981	21103 - 01101	2439 - 2493	130	1.005E-24	3.715E-27	1.076E-26	35
2500.760	20003 - 00001	2459 - 2544	115	1.399E-23	3.950E-27	2.624E-25	57
2614.248	20002 - 00001	2569 - 2657	119	2.281E-23	3.981E-27	4.310E-25	59
2618.644	21102 - 01101	2590 - 2648	146	1.483E-24	3.778E-27	1.515E-26	38
2757.178	20001 - 00001	2723 - 2797	98	3.261E-24	3.744E-27	6.196E-26	49
3281.017	21102 - 00001	3289 - 3315	36	2.846E-25	3.762E-27	1.082E-26	45
3504.333	21113 - 11102	3472 - 3530	146	1.493E-24	3.781E-27	1.514E-26	38
3509.227	21112 - 11101	3490 - 3526	58	2.464E-25	3.764E-27	4.658E-27	24
3511.418	12212 - 02201	3465 - 3545	236	1.411E-23	3.833E-27	1.329E-25	53
3531.835	20013 - 10002	3480 - 3567	119	1.873E-23	3.781E-27	3.483E-25	59
3538.777	11112 - 01101	3474 - 3577	334	3.828E-22	4.211E-27	3.563E-24	69
3539.017	20012 - 10001	3488 - 3569	109	7.737E-24	3.737E-27	1.451E-25	54
3571.140	10012 - 00001	3491 - 3612	165	5.312E-21	4.629E-27	9.867E-23	82
3645.435	20012 - 10002	3593 - 3678	115	1.440E-23	3.785E-27	2.704E-25	57
3656.829	21112 - 11102	3627 - 3680	130	1.042E-24	3.860E-27	1.111E-26	35
3675.133	10011 - 00001	3599 - 3719	163	4.660E-21	4.003E-27	8.755E-23	81
3676.739	20011 - 10001	3629 - 3711	111	1.063E-23	4.046E-27	2.000E-25	55
3677.708	21111 - 11101	3651 - 3700	112	7.185E-25	3.709E-27	8.245E-27	32
3683.813	11111 - 01101	3619 - 3723	336	4.118E-22	3.993E-27	3.858E-24	69
3687.474	12211 - 02201	3639 - 3720	242	1.704E-23	3.939E-27	1.600E-25	54
3856.658	30003 - 00001	3823 - 3888	85	1.421E-24	4.122E-27	2.710E-26	43
3987.595	30002 - 00001	3961 - 4015	66	5.530E-25	3.823E-27	1.171E-26	36
4614.779	01121 - 01101	4583 - 4634	122	8.809E-25	3.712E-27	9.702E-27	34
4639.501	00021 - 00001	4580 - 4663	113	1.236E-23	4.075E-27	2.323E-25	56
4743.697	21113 - 01101	4704 - 4774	184	4.494E-24	4.122E-27	4.284E-26	46
4791.260	20013 - 00001	4733 - 4828	129	5.441E-23	4.262E-27	1.005E-24	64
4896.193	21112 - 01101	4851 - 4927	204	9.079E-24	4.233E-27	8.610E-26	50
4904.860	20012 - 00001	4841 - 4940	135	1.290E-22	4.279E-27	2.414E-24	67

[*continued*. . .]

Table 2—*continued*

ν_o	$v' - v''$	ν_{min} - ν_{max}	#lines	ΣS	S_{min}	S_{max}	J''_{max}
5042.583	20011 - 00001	4992 - 5080	119	2.446E-23	3.920E-27	4.623E-25	59
5064.674	21111 - 01101	5029 - 5093	168	2.626E-24	3.731E-27	2.575E-26	42
5858.028	10022 - 00001	5829 - 5876	54	3.320E-25	3.867E-27	7.879E-27	32
5959.956	10021 - 00001	5935 - 5977	45	2.326E-25	3.774E-27	6.102E-27	28
5993.586	30014 - 00001	5969 - 6016	54	3.266E-25	3.811E-27	7.605E-27	32
6127.783	30013 - 00001	6086 - 6154	93	2.175E-24	3.862E-27	4.106E-26	46
6254.594	30012 - 00001	6219 - 6281	81	1.131E-24	3.818E-27	2.227E-26	41
6885.154	01131 - 01101	6863 - 6898	58	2.449E-25	3.748E-27	4.632E-27	24
6922.197	00031 - 00001	6860 - 6938	105	5.870E-24	3.945E-27	1.106E-25	52
8120.109	10032 - 00001	8103 - 8133	16	6.207E-26	3.726E-27	4.060E-27	21
Total Number of lines for the $^{16}O^{12}C^{17}O$ (627) isotope is: 6,625							
579.1417	20002 - 11101	578 - 579	16	1.839E-26	1.001E-27	1.242E-27	24
586.8501	11102 - 02201	554 - 618	240	3.941E-24	3.709E-27	3.769E-26	45
607.5550	20003 - 11102	590 - 627	74	3.662E-25	1.041E-27	9.046E-27	44
607.5575	10002 - 01101	559 - 655	191	1.104E-22	3.892E-27	2.036E-24	66
644.4065	11102 - 10002	606 - 687	161	1.432E-23	3.946E-27	2.640E-25	56
649.9549	12202 - 11102	633 - 673	134	8.467E-25	3.704E-27	1.031E-26	34
664.7291	01101 - 00001	608 - 729	239	5.940E-21	3.777E-27	1.087E-22	81
665.1139	02201 - 01101	617 - 722	396	4.685E-22	3.776E-27	4.279E-24	69
665.5090	03301 - 02201	628 - 709	308	2.709E-23	3.943E-27	2.458E-25	56
681.3863	12201 - 11101	681 - 700	114	5.084E-25	1.101E-27	7.213E-27	42
686.0712	11101 - 10001	647 - 727	158	1.250E-23	4.107E-27	2.306E-25	55
711.2983	10001 - 01101	662 - 759	192	1.215E-22	3.981E-27	2.241E-24	66
713.4590	20001 - 11101	712 - 714	25	1.405E-25	3.707E-27	6.758E-27	30
724.5473	20002 - 11102	721 - 725	37	1.081E-25	1.059E-27	4.273E-27	38
732.2557	11101 - 02201	700 - 764	240	4.389E-24	4.072E-27	4.195E-26	45
748.1330	12201 - 03301	747 - 749	54	9.417E-26	1.024E-27	2.182E-27	32
789.8120	11101 - 10002	765 - 817	97	8.764E-25	3.759E-27	1.800E-26	39
963.9862	00011 - 10001	937 - 986	56	3.657E-25	3.863E-27	8.555E-27	32
1067.727	00011 - 10002	1037 - 1092	66	5.674E-25	3.819E-27	1.220E-26	36
1272.287	10002 - 00001	1239 - 1307	87	1.538E-24	3.709E-27	2.888E-26	44
1376.027	10001 - 00001	1342 - 1412	91	2.117E-24	3.740E-27	4.126E-26	45
1916.693	11102 - 00001	1884 - 1918	59	4.317E-25	3.778E-27	1.197E-26	44
2062.099	11101 - 00001	2021 - 2075	115	3.332E-24	3.718E-27	6.727E-26	55
2110.829	20001 - 01101	2086 - 2102	21	9.863E-26	3.790E-27	5.255E-27	33
2306.741	11112 - 11102	2260 - 2339	210	1.142E-23	3.997E-27	1.100E-25	51
2315.147	02211 - 02201	2253 - 2353	322	1.887E-22	3.858E-27	1.790E-24	65
2317.319	10011 - 10001	2256 - 2354	130	8.040E-23	3.720E-27	1.533E-24	65
2318.964	10012 - 10002	2256 - 2357	134	1.289E-22	3.792E-27	2.457E-24	67
2327.581	01111 - 01101	2251 - 2369	400	4.950E-21	4.070E-27	4.714E-23	78
2340.014	00011 - 00001	2249 - 2384	179	6.785E-20	4.532E-27	1.284E-21	89
2524.248	20003 - 00001	2499 - 2551	59	4.284E-25	3.867E-27	9.657E-27	33
2641.240	20002 - 00001	2610 - 2673	80	1.088E-24	3.751E-27	2.171E-26	41
2775.558	20001 - 00001	2762 - 2793	16	6.210E-26	3.716E-27	4.074E-27	21
3549.229	20013 - 10002	3510 - 3579	91	2.194E-24	4.071E-27	4.259E-26	45
3558.705	11112 - 01101	3503 - 3595	272	6.642E-23	3.993E-27	6.325E-25	60
3563.323	20012 - 10001	3525 - 3589	83	1.299E-24	3.716E-27	2.566E-26	42
3591.251	10012 - 00001	3519 - 3632	149	8.408E-22	4.189E-27	1.599E-23	74
3667.064	20012 - 10002	3622 - 3696	97	3.288E-24	3.840E-27	6.330E-26	48
3692.903	20011 - 10001	3651 - 3724	95	2.748E-24	3.755E-27	5.303E-26	47
3693.346	10011 - 00001	3621 - 3735	151	1.020E-21	3.913E-27	1.939E-23	75
3702.083	11111 - 01101	3644 - 3739	278	7.668E-23	4.001E-27	7.299E-25	61

[*continued*...]

Table 2—*continued*

ν_o	$\nu' - \nu''$	ν_{min} - ν_{max}	#lines	ΣS	S_{min}	S_{max}	J''_{max}
4655.204	00021 - 00001	4614 - 4677	81	1.215E-24	3.997E-27	2.412E-26	41
4821.515	20013 - 00001	4774 - 4856	107	7.405E-24	3.723E-27	1.413E-25	53
4928.916	21112 - 01101	4896 - 4954	138	1.342E-24	3.763E-27	1.409E-26	37
4939.351	20012 - 00001	4884 - 4972	118	2.306E-23	3.829E-27	4.388E-25	59
5068.930	20011 - 00001	5023 - 5103	105	6.284E-24	3.772E-27	1.200E-25	52
6175.954	30013 - 00001	6152 - 6195	44	2.244E-25	3.712E-27	6.075E-27	28
6298.116	30012 - 00001	6277 - 6317	36	1.654E-25	3.763E-27	5.221E-27	26
6945.608	00031 - 00001	6901 - 6962	79	1.065E-24	4.008E-27	2.125E-26	40
Total Number of lines for the $^{16}O^{13}C^{18}O$ (638) isotope is: 2,312							
601.5712	10002 - 01101	567 - 637	144	5.078E-24	4.083E-27	9.349E-26	51
643.3290	01101 - 00001	595 - 697	208	3.393E-22	4.200E-27	6.144E-24	71
643.6530	02201 - 01101	606 - 687	320	2.834E-23	3.865E-27	2.561E-25	57
698.9488	10001 - 01101	663 - 734	147	5.479E-24	3.717E-27	1.007E-25	52
1244.900	10002 - 00001	1229 - 1264	29	1.238E-25	3.705E-27	4.796E-27	24
1342.278	10001 - 00001	1317 - 1369	64	5.295E-25	4.017E-27	1.163E-26	35
2242.807	02211 - 02201	2196 - 2275	236	1.449E-23	3.934E-27	1.367E-25	53
2245.272	10011 - 10001	2200 - 2277	104	5.467E-24	3.837E-27	1.034E-25	52
2245.495	10012 - 10002	2198 - 2278	109	8.050E-24	3.765E-27	1.520E-25	54
2254.380	01111 - 01101	2191 - 2293	332	3.438E-22	3.813E-27	3.229E-24	69
2265.971	00011 - 00001	2188 - 2308	163	3.848E-21	3.800E-27	7.229E-23	81
2588.182	20002 - 00001	2571 - 2606	26	1.080E-25	3.717E-27	4.507E-27	23
3490.396	10012 - 00001	3434 - 3528	127	4.590E-23	3.777E-27	8.611E-25	63
3587.550	10011 - 00001	3527 - 3624	131	6.970E-23	3.731E-27	1.307E-24	65
4692.179	20013 - 00001	4673 - 4711	32	1.391E-25	3.762E-27	4.832E-27	25
4814.570	20012 - 00001	4777 - 4840	83	1.276E-24	3.919E-27	2.490E-26	42
4925.013	20011 - 00001	4898 - 4947	57	3.639E-25	3.746E-27	8.287E-27	32
Total Number of lines for the $^{16}O^{13}C^{17}O$ (637) isotope is: 1,584							
609.586	10002 - 01101	584 - 636	97	8.953E-25	3.791E-27	1.845E-26	39
645.744	01101 - 00001	602 - 694	182	6.147E-23	4.367E-27	1.130E-24	63
646.083	02201 - 01101	616 - 682	247	5.106E-24	3.711E-27	4.802E-26	46
709.373	10001 - 01101	684 - 734	95	8.030E-25	3.709E-27	1.670E-26	39
2250.798	02211 - 02201	2215 - 2279	166	2.467E-24	3.758E-27	2.475E-26	42
2253.046	10012 - 10002	2216 - 2281	83	1.404E-24	3.985E-27	2.778E-26	42
2253.442	10011 - 10001	2219 - 2279	75	9.178E-25	3.935E-27	1.867E-26	39
2262.453	01111 - 01101	2206 - 2298	272	6.242E-23	3.752E-27	5.956E-25	60
2274.088	00011 - 00001	2203 - 2315	148	7.146E-22	3.746E-27	1.362E-23	74
3508.376	10012 - 00001	3461 - 3543	107	7.671E-24	3.842E-27	1.466E-25	53
3608.559	10011 - 00001	3557 - 3642	112	1.256E-23	3.767E-27	2.395E-25	56
Total Number of lines for the $^{12}C^{18}O_2$ (828) isotope is: 721							
657.3310	01101 - 00001	615 - 703	96	3.291E-23	4.335E-27	1.156E-24	66
657.7532	02201 - 01101	629 - 691	129	2.576E-24	3.928E-27	4.642E-26	48
2289.569	02211 - 02201	2255 - 2315	83	1.175E-24	3.720E-27	2.276E-26	43
2290.972	10011 - 10001	2258 - 2315	39	4.544E-25	4.060E-27	1.769E-26	40
2294.879	10012 - 10002	2259 - 2321	44	7.690E-25	4.144E-27	2.895E-26	44
2301.800	01111 - 01101	2248 - 2335	140	3.080E-23	3.784E-27	5.615E-25	63
2314.048	00011 - 00001	2245 - 2351	77	3.597E-22	4.727E-27	1.309E-23	76
3525.204	10012 - 00001	3477 - 3556	58	5.857E-24	3.702E-27	2.134E-25	58
3638.065	10011 - 00001	3594 - 3670	55	3.896E-24	4.734E-27	1.423E-25	54

[*continued...*]

Table 2—*continued*

ν_o	$v' - v''$	ν_{min} - ν_{max}	#lines	ΣS	S_{min}	S_{max}	J''_{max}
Total Number of lines for the $^{17}O^{12}C^{18}O$ (728) isotope is: 288							
659.7057	01101 - 00001	626 - 697	150	6.045E-24	3.966E-27	1.088E-25	53
2322.436	00011 - 00001	2261 - 2359	138	1.350E-22	3.866E-27	2.495E-24	69
Total Number of lines for the $^{16}O_3$ (666) isotope is: 142,221							
	011 - 110	92 - 107	20	1.447E-24	4.370E-26	9.150E-26	32
	001 - 100	37 - 125	235	1.287E-22	1.720E-26	4.260E-24	59
	000 - 000	0 - 266	5493	4.470E-19	5.430E-29	1.490E-21	79
	010 - 010	0 - 161	3172	1.449E-20	4.060E-29	4.840E-23	74
	001 - 001	0 - 144	2287	2.564E-21	2.040E-28	9.130E-24	64
	100 - 100	0 - 144	2126	1.871E-21	4.430E-28	6.700E-24	64
	020 - 020	2 - 135	1604	4.582E-22	1.730E-27	1.580E-24	59
	011 - 011	3 - 121	939	8.359E-23	2.220E-27	3.220E-25	49
	110 - 110	3 - 118	794	5.564E-23	1.910E-27	2.260E-25	47
61.0533	100 - 001	11 - 125	849	2.039E-22	1.780E-26	3.950E-24	59
69.7394	110 - 011	80 - 108	27	1.514E-24	3.310E-26	7.960E-26	31
341.1529	001 - 010	290 - 374	1220	1.001E-21	7.700E-26	3.330E-24	52
402.2062	100 - 010	322 - 388	30	2.823E-24	7.980E-26	1.050E-25	33
623.3852	011 - 100	596 - 808	102	2.521E-23	9.530E-26	6.770E-25	39
681.4119	021 - 011	612 - 770	923	1.958E-22	9.570E-26	7.710E-25	46
684.4385	011 - 001	580 - 821	2722	3.596E-21	9.550E-26	1.080E-23	61
690.3148	120 - 110	629 - 766	668	1.181E-22	9.580E-26	5.390E-25	43
693.1246	110 - 100	591 - 826	2490	2.624E-21	9.550E-26	7.820E-24	58
698.3415	020 - 010	575 - 839	4232	3.879E-20	9.420E-26	1.130E-22	61
700.9311	010 - 000	558 - 897	7150	5.921E-19	9.400E-26	1.710E-21	79
754.1779	110 - 001	593 - 807	100	2.461E-23	9.560E-26	6.680E-25	39
929.8447	012 - 110	931 - 1010	164	3.290E-23	1.010E-25	7.410E-25	49
954.7535	002 - 100	919 - 1048	951	3.266E-21	1.000E-25	4.040E-23	66
988.9772	111 - 110	924 - 1018	1342	2.102E-21	1.000E-25	6.460E-24	54
999.5841	012 - 011	936 - 1032	1603	5.996E-21	1.000E-25	1.810E-23	59
1007.6470	101 - 100	919 - 1180	2646	6.246E-20	1.000E-25	1.900E-22	68
1008.6618	021 - 020	949 - 1056	1511	1.497E-20	1.000E-25	4.560E-23	51
1015.8068	002 - 001	937 - 1194	3137	1.680E-19	1.000E-25	5.030E-22	70
1025.5914	011 - 010	937 - 1218	3883	4.635E-19	1.000E-25	1.380E-21	71
1042.0840	001 - 000	921 - 1244	7224	1.413E-17	1.000E-25	4.200E-20	87
1058.7166	111 - 011	948 - 1091	252	6.379E-23	1.010E-25	2.150E-24	49
1068.7003	101 - 001	934 - 1202	2558	5.238E-21	1.000E-25	7.040E-23	62
1087.3041	120 - 020	1026 - 1171	820	2.207E-22	1.000E-25	1.730E-24	54
1089.9162	210 - 110	1084 - 1153	177	3.331E-23	1.000E-25	5.370E-25	46
1095.3308	110 - 010	948 - 1233	3885	1.273E-20	1.000E-25	8.240E-23	69
1098.0179	200 - 100	955 - 1215	2931	3.299E-21	1.000E-25	1.930E-23	66
1103.1373	100 - 000	943 - 1271	6766	5.403E-19	1.000E-25	3.470E-21	83
1159.0712	200 - 001	976 - 1230	2057	8.340E-21	1.000E-25	2.600E-23	59
1159.6556	210 - 011	1130 - 1201	593	1.652E-22	1.000E-25	6.160E-25	38
1356.9597	002 - 010	1319 - 1431	107	2.064E-23	1.000E-25	4.160E-25	35
1399.2726	020 - 000	1332 - 1495	1127	4.499E-22	1.000E-25	3.010E-24	40
1409.8532	101 - 010	1358 - 1435	1043	9.927E-22	1.010E-25	3.260E-24	40
1707.0034	021 - 010	1644 - 1749	1365	3.421E-21	1.000E-25	1.120E-23	51
1726.5225	011 - 000	1634 - 1927	3415	5.357E-20	1.000E-25	1.720E-22	68
1785.6456	120 - 010	1712 - 1877	1621	1.372E-21	1.000E-25	7.040E-24	59
1796.2619	110 - 000	1666 - 1963	3695	2.374E-20	1.000E-25	1.090E-22	69
1942.9509	003 - 100	1856 - 2094	1285	1.379E-21	1.000E-25	4.490E-24	54

[*continued*...]

Table 2—*continued*

ν_o	$\nu' - \nu''$	$\nu_{min} - \nu_{max}$	#lines	ΣS	S_{min}	S_{max}	J''_{max}
1980.5651	102 - 100	1875 - 2064	1245	3.838E-22	1.000E-25	2.170E-24	47
2004.0042	003 - 001	1891 - 2086	1685	1.189E-21	1.000E-25	1.170E-23	57
2025.1755	012 - 010	1902 - 2110	2506	3.156E-21	1.000E-25	4.590E-23	64
2041.6184	102 - 001	1965 - 2067	2175	1.562E-20	1.000E-25	4.650E-23	61
2057.8908	002 - 000	1882 - 2278	5339	1.120E-19	1.070E-25	5.860E-22	71
2083.2724	201 - 100	1999 - 2132	1976	1.049E-20	1.000E-25	3.030E-23	61
2084.3080	111 - 010	1930 - 2221	2514	4.083E-20	1.000E-25	1.200E-22	66
2110.7843	101 - 000	1913 - 2322	5865	1.236E-18	1.070E-25	3.650E-21	78
2144.3257	201 - 001	2015 - 2223	1300	4.579E-22	1.000E-25	1.960E-24	54
2185.2470	210 - 010	2065 - 2252	1639	7.633E-22	1.000E-25	4.900E-24	60
2201.1552	200 - 000	1935 - 2322	5024	3.371E-20	1.070E-25	1.810E-22	73
2407.9345	021 - 000	2345 - 2431	948	4.188E-22	7.320E-26	1.520E-24	48
2486.5766	120 - 000	2407 - 2552	1176	3.842E-22	7.250E-26	1.650E-24	54
2726.1066	012 - 000	2618 - 2816	2630	3.301E-21	8.930E-26	2.680E-23	64
2785.2391	111 - 000	2639 - 2918	2390	2.425E-20	8.930E-26	7.620E-23	62
2886.1781	210 - 000	2768 - 2994	1973	1.101E-21	8.930E-26	6.130E-24	62
3046.0882	003 - 000	2928 - 3202	3318	1.312E-19	1.010E-25	4.020E-22	61
3083.7024	102 - 000	2941 - 3176	3160	1.265E-20	1.000E-25	6.780E-23	61
3186.4097	201 - 000	2934 - 3227	2017	9.300E-21	1.000E-25	2.570E-23	59
Total Number of lines for the $^{16}O^{16}O^{18}O$ (668) isotope is: 19,147							
	000 - 000	0 - 130	3658	1.666E-21	4.880E-28	2.760E-24	63
	010 - 010	7 - 103	1105	4.383E-23	4.120E-27	9.960E-26	42
684.6134	010 - 000	592 - 799	3996	2.096E-21	9.520E-26	2.960E-24	51
1028.1120	001 - 000	954 - 1124	4343	5.262E-20	9.960E-26	7.760E-23	65
1090.3541	100 - 000	968 - 1178	6045	4.424E-21	9.960E-26	1.640E-23	60
Total Number of lines for the $^{16}O^{18}O^{16}O$ (686) isotope is: 7,513							
	000 - 000	1 - 129	1825	8.094E-22	7.500E-28	2.780E-24	62
	010 - 010	7 - 99	506	1.909E-23	3.780E-27	9.360E-26	40
693.3057	010 - 000	605 - 809	1980	1.060E-21	9.560E-26	3.240E-24	50
1008.4528	001 - 000	934 - 1071	2184	2.657E-20	9.920E-26	7.560E-23	65
1074.3076	100 - 000	969 - 1146	1018	4.974E-22	9.960E-26	3.840E-24	46
Total Number of lines for the $^{12}C^{16}O$ (26) isotope is: 800							
	0 - 0	3 - 190	50	1.817E-20	1.926E-29	1.449E-21	49
	1 - 1	3 - 188	50	3.129E-25	3.188E-34	2.494E-26	49
2116.7912	2 - 1	1886 - 2260	100	6.164E-22	1.727E-32	2.745E-23	50
2143.2716	1 - 0	1911 - 2288	100	1.036E-17	2.355E-28	4.636E-19	50
4207.1680	3 - 1	3933 - 4306	100	7.032E-24	1.672E-34	3.213E-25	50
4260.0627	2 - 0	3985 - 4361	100	7.692E-20	1.480E-30	3.532E-21	50
6271.1982	4 - 1	5955 - 6338	100	6.216E-26	1.132E-36	2.942E-27	50
6350.4396	3 - 0	6032 - 6418	100	4.909E-22	7.139E-33	2.338E-23	50
8414.4698	4 - 0	8053 - 8465	100	1.531E-24	4.174E-36	8.159E-26	50
Total Number of lines for the $^{13}C^{16}O$ (36) isotope is: 700							
	0 - 0	3 - 182	50	1.943E-22	5.344E-31	1.520E-23	49
	1 - 1	3 - 180	50	4.274E-27	1.143E-35	3.343E-28	49
2070.7523	2 - 1	1851 - 2209	100	8.246E-24	6.127E-34	3.592E-25	50

[*continued...*]

Table 2—*continued*

ν_o	$v' - v''$	$\nu_{min} - \nu_{max}$	#lines	ΣS	S_{min}	S_{max}	J''_{max}
2096.0674	1 - 0	1874 - 2236	100	1.102E-19	6.735E-30	4.823E-21	50
4116.2514	3 - 1	3856 - 4213	100	9.186E-26	5.805E-36	4.102E-27	50
4166.8198	2 - 0	3905 - 4265	100	7.992E-22	4.144E-32	3.587E-23	50
6136.5608	4 - 1	5836 - 6202	100	7.918E-28	3.847E-38	3.660E-29	50
6212.3188	3 - 0	5911 - 6279	100	4.976E-24	1.959E-34	2.315E-25	50
Total Number of lines for the $^{12}C^{18}O$ (28) isotope is: 700							
	0 - 0	3 - 181	50	3.490E-23	1.038E-31	2.726E-24	49
	1 - 1	3 - 179	50	7.837E-28	2.268E-36	6.119E-29	49
2066.9041	2 - 1	1848 - 2205	100	1.509E-24	1.216E-34	6.562E-26	50
2092.1231	1 - 0	1871 - 2231	100	1.979E-20	1.312E-30	8.643E-22	50
4108.6486	3 - 1	3850 - 4205	100	1.678E-26	1.150E-36	7.479E-28	50
4159.0272	2 - 0	3898 - 4257	100	1.432E-22	8.060E-33	6.416E-24	50
6128.8319	4 - 1	5827 - 6190	100	1.443E-28	7.605E-39	6.658E-30	50
6200.7717	3 - 0	5900 - 6267	100	8.900E-25	3.804E-35	4.132E-26	50
Total Number of lines for the $^{12}C^{17}O$ (27) isotope is: 700							
	0 - 0	3 - 185	50	6.771E-24	1.242E-32	5.344E-25	49
	1 - 1	3 - 183	50	1.341E-28	2.380E-37	1.058E-29	49
2090.4835	2 - 1	1866 - 2231	100	2.611E-25	1.281E-35	1.148E-26	50
2116.2957	1 - 0	1890 - 2258	100	3.849E-21	1.544E-31	1.701E-22	50
4155.2213	3 - 1	3889 - 4253	100	2 938E-27	1.225E-37	1.325E-28	50
4206.7792	2 - 0	3939 - 4306	100	2.820E-23	9.588E-34	1.278E-24	50
6194.2758	4 - 1	5887 - 6260	100	2.561E-29	8.194E-40	1.196E-30	50
6271.5170	3 - 0	5963 - 6339	100	1.775E-25	4.573E-36	8.341E-27	50
Total Number of lines for the $^{13}C^{18}O$ (38) isotope is: 700							
	0 - 0	3 - 173	50	3.723E-25	2.863E-33	2.840E-26	49
	1 - 1	3 - 171	50	1.075E-29	8.113E-38	8.196E-31	49
2019.639	2 - 1	1811 - 2152	100	2.027E-26	4.324E-36	8.598E-28	50
2043.992	1 - 0	1834 - 2178	100	2.099E-22	3.739E-32	8.949E-24	50
4015.283	3 - 1	3770 - 4109	100	2.198E-28	3.998E-38	9.552E-30	50
4063.331	2 - 0	3816 - 4159	100	1.483E-24	2.247E-34	6.478E-26	50
5986.988	4 - 1	5705 - 6051	100	1.841E-30	2.585E-40	8.273E-32	50
6058.975	3 - 0	5775 - 6124	100	8.980E-27	1.038E-36	4.062E-28	50
Total Number of lines for the $^{12}CH_4$ (211) isotope is: 36,032							
	00000000 - 00000000	0 - 313	1747	1.975E-23	4.060E-34	6.870E-25	29
	00000111 - 00000111	2 - 368	2207	2.205E-23	4.040E-29	5.990E-25	19
	01100001 - 01100001	62 - 198	110	1.255E-26	4.050E-29	5.000E-28	18
222.5709	01100001 - 00000111	26 - 579	2297	8.701E-24	4.040E-29	1.350E-25	19
1296.9835	01100112 - 01100001	1127 - 1481	1813	5.735E-21	4.040E-26	5.340E-23	13
1303.4989	00000222 - 00000111	1109 - 1606	2397	3.659E-20	4.040E-26	3.820E-22	13
1310.7616	00000111 - 00000000	992 - 1767	3198	4.783E-18	4.050E-26	9.680E-20	24
1383.1448	10000000 - 01100001	1223 - 1503	342	7.219E-23	4.050E-26	1.600E-24	13
1486.1618	00011001 - 01100001	1329 - 1606	768	3.450E-22	4.040E-26	5.240E-24	13
1519.5545	01100112 - 00000111	1341 - 1717	1214	3.040E-22	4.040E-26	3.150E-24	13
1531.8099	02200002 - 01100001	1412 - 1672	500	8.581E-23	4.050E-26	1.300E-24	13
1533.3326	01100001 - 00000000	1149 - 1799	1973	4.152E-19	4.060E-26	5.580E-20	24
1605.7158	10000000 - 00000111	1553 - 1696	135	2.023E-23	4.190E-26	4.050E-25	12

[*continued*...]

Table 2—*continued*

ν_o	v' - v"	ν_{min} - ν_{max}	#lines	ΣS	S_{min}	S_{max}	J''_{max}
1708.7328	00011001 - 00000111	1505 - 1932	1833	1.911E-21	4.030E-26	2.340E-23	13
1754.3809	02200002 - 00000111	1700 - 1969	189	2.203E-23	4.050E-26	6.710E-25	11
2587.0465	00000202 - 00000000	2458 - 2682	41	5.420E-22	3.390E-24	4.640E-23	14
2614.2605	00000222 - 00000000	2255 - 2848	1266	5.500E-20	1.320E-24	8.390E-22	17
2838.1964	01100112 - 00000000	2573 - 3168	2300	3.768E-19	1.220E-24	5.180E-21	18
2916.4773	10000000 - 00000000	2764 - 3068	52	1.159E-21	3.310E-24	1.200E-22	15
3008.518	00011112 - 00000111	2880 - 3136	712	4.445E-20	2.200E-24	6.170E-22	13
3010.392	01111002 - 01100001	2898 - 3106	264	6.801E-21	1.400E-24	2.770E-22	10
3019.4944	00011001 - 00000000	2809 - 3210	1903	1.080E-17	1.480E-24	2.130E-19	20
3064.3951	02200002 - 00000000	2919 - 3254	754	3.401E-20	1.000E-24	7.160E-22	17
3870.5	00000333 - 00000000	3871 - 3891	11	3.386E-21	1.910E-22	5.250E-22	4
4223.458	10000111 - 00000000	4136 - 4279	172	2.402E-19	1.900E-22	5.240E-21	13
4319.280	00011112 - 00000000	4147 - 4490	956	4.072E-19	1.560E-23	5.530E-21	13
4540.609	01111002 - 00000000	4409 - 4667	388	6.246E-20	2.050E-23	1.210E-21	12
5588.	00011223 - 00000000	5586 - 5625	11	1.225E-21	4.920E-24	2.120E-22	3
6004.991	00022002 - 00000000	5891 - 6107	144	5.973E-20	4.060E-23	1.320E-21	10
	- 00000000	3701 - 6185	5496	2.057E-19	4.000E-25	2.380E-21	
	-	2511 - 3176	839	1.453E-20	1.000E-24	1.100E-21	
Total Number of lines for the $^{13}CH_4$ (311) isotope is: 4,926							
	00000000 - 00000000	0 - 310	1286	2.192E-25	4.100E-34	7.620E-27	29
	00000111 - 00000111	19 - 341	508	2.458E-25	4.030E-29	7.040E-27	17
230.7122	01100001 - 00000111	78 - 402	446	9.389E-26	4.040E-29	1.630E-27	14
1302.7806	00000111 - 00000000	1089 - 1686	1246	5.025E-20	4.050E-26	1.010E-21	21
1533.4928	01100001 - 00000000	1170 - 1733	724	4.317E-21	4.060E-26	5.900E-22	20
2596.6398	00000222 - 00000000	2461 - 2728	36	1.772E-22	1.230E-24	2.200E-23	8
2822.4513	01100112 - 00000000	2659 - 2999	208	2.805E-21	2.080E-24	5.960E-23	11
3000.	00011112 - 00000111	3034 - 3091	12	5.906E-23	3.410E-24	1.050E-23	9
3009.5455	00011001 - 00000000	2832 - 3168	373	9.053E-20	1.940E-24	2.250E-21	18
5985.	00022002 - 00000000	5898 - 6070	83	5.161E-22	1.150E-24	1.940E-23	8
	-	3157 - 3175	4	1.302E-22	1.280E-23	6.490E-23	
Total Number of lines for the $^{12}CH_3D$ (212) isotope is: 6,457							
	GROUND - GROUND	7 - 101	80	4.241E-26	5.570E-30	1.510E-27	12
1161.105	V6 - GROUND	904 - 1487	2081	1.462E-21	1.000E-27	1.940E-23	19
1306.845	V3 - GROUND	1035 - 1479	1003	1.049E-21	1.010E-27	2.160E-23	19
1472.024	V5 - GROUND	1250 - 1696	1873	3.535E-22	1.010E-27	4.900E-24	19
2200.0390	V2 - GROUND	2005 - 2356	499	4.634E-22	1.260E-28	9.120E-24	20
2300.	2V6 - GROUND	2088 - 2434	612	1.148E-22	6.136E-28	2.148E-24	14
3000.	V4 - GROUND	2903 - 3147	242	6.579E-21	3.320E-24	4.030E-22	17
3000.	V1 - GROUND	2902 - 3071	28	4.722E-22	3.470E-24	9.870E-23	11
3000.	2V5 - GROUND	2902 - 3130	39	4.420E-22	3.310E-24	1.070E-22	12
Total Number of lines for the $^{32}S^{16}O_2$ (626) isotope is: 25,938							
	000 - 000	0 - 257	9622	2.583E-18	1.020E-28	6.190E-21	74
517.75	010 - 000	433 - 617	3326	3.899E-18	1.380E-24	7.080E-21	50
1151.7130	100 - 000	1043 - 1260	6835	3.519E-18	5.845E-24	5.841E-21	66
1362.0607	001 - 000	1311 - 1400	3618	3.080E-17	6.097E-23	6.094E-20	66
2492.4438	111 - 010	2463 - 2516	654	2.110E-20	1.018E-23	6.299E-23	45
2499.8701	101 - 000	2463 - 2527	1883	3.954E-19	1.030E-23	7.836E-22	59

[*continued*. . .]

Table 2—*continued*

ν_o	$v' - v''$	$\nu_{min} - \nu_{max}$	#lines	ΣS	S_{min}	S_{max}	J''_{max}
Total Number of lines for the $^{34}S^{16}O_2$ (646) isotope is: 287							
2475.8300	101 - 000	2463 - 2497	287	6.027E-21	9.736E-24	3.428E-23	40
Total Number of lines for the $^{14}N^{16}O_2$ (646) isotope is: 55,468							
	000 - 000	0 - 224	22056	3.329E-19	6.050E-28	2.330E-22	65
	010 - 010	0 - 207	10168	8.741E-21	4.240E-28	6.250E-24	59
749.6541	010 - 000	586 - 1001	8064	5.437E-19	2.830E-25	1.080E-21	65
1498.3461	020 - 000	1550 - 1659	464	5.746E-20	5.010E-24	5.900E-22	61
1616.852	001 - 000	1533 - 1698	5821	5.709E-17	5.000E-24	1.320E-19	70
1605.4973	011 - 010	1540 - 1648	3220	1.450E-18	5.010E-24	3.420E-21	64
2805.5122	120 - 000	2860 - 2926	57	3.327E-22	5.000E-24	6.780E-24	43
2898.1930	111 - 010	2832 - 2918	1829	1.056E-19	5.000E-24	2.470E-22	52
2906.0691	101 - 000	2828 - 2939	3789	2.882E-18	5.010E-24	6.430E-21	66
Total Number of lines for the $H^{14}N^{16}O_3$ (146) isotope is: 143,021							
	GROUND - GROUND	0 - 43	4182	5.819E-19	3.490E-27	1.460E-21	40
458.2287	V9 - GROUND	410 - 500	8091	1.082E-17	5.231E-23	1.046E-20	53
580.3035	V7 - GROUND	545 - 614	8013	9.537E-19	2.420E-23	6.491E-22	65
648.8262	V6 - GROUND	615 - 678	8379	1.262E-18	2.830E-23	8.540E-22	65
763.1543	V8 - GROUND	722 - 810	7101	1.242E-18	1.211E-23	1.090E-21	65
879.1085	V5 - GROUND	840 - 918	8313	1.261E-17	8.160E-23	1.560E-20	61
877.	V5+V9 - V9	847 - 905	3971	1.216E-18	8.130E-23	1.700E-21	61
885.	3V9 - V9	845 - 909	4780	2.030E-18	8.140E-23	2.780E-21	61
896.4480	2V9 - GROUND	852 - 920	7250	9.843E-18	8.140E-23	1.280E-20	61
1205.7070	V8+V9 - GROUND	1165 - 1233	9709	1.199E-18	1.613E-23	7.920E-22	65
1303.5182	V4 - GROUND	1229 - 1388	19584	1.232E-17	1.000E-23	1.800E-20	75
1325.7354	V3 - GROUND	1098 - 1388	21308	2.446E-17	1.000E-23	3.020E-20	75
1709.5675	V2 - GROUND	1650 - 1770	32340	4.381E-17	2.119E-24	2.119E-20	75
Total Number of lines for the $H^{19}F$ (19) isotope is: 107							
	0 - 0	41 - 625	16	5.705E-17	8.902E-26	1.460E-17	15
	1 - 1	79 - 275	6	2.481E-25	1.560E-26	6.543E-26	6
3961.4429	1 - 0	3269 - 4369	29	1.572E-17	1.149E-26	2.369E-18	14
3789.3520	2 - 1	3666 - 3933	7	1.041E-25	1.105E-26	1.926E-26	3
7750.7949	2 - 0	6999 - 7995	26	4.963E-19	1.374E-26	7.693E-20	13
11372.8057	3 - 0	10684 - 11536	23	1.232E-20	2.577E-26	1.924E-21	11
Total Number of lines for the $H^{35}Cl$ (15) isotope is: 203							
	0 - 0	20 - 438	22	8.096E-18	1.948E-26	1.452E-18	21
	1 - 1	20 - 260	13	6.902E-24	1.976E-26	1.225E-24	12
2782.0067	2 - 1	2554 - 2963	21	7.419E-24	1.433E-26	7.709E-25	10
2885.9765	1 - 0	2400 - 3161	39	4.750E-18	1.811E-26	5.034E-19	19
5460.8006	3 - 1	5321 - 5569	13	2.738E-25	1.128E-26	3.224E-26	6
5667.9832	2 - 0	5159 - 5830	35	1.077E-19	2.294E-26	1.179E-20	17
8346.7771	3 - 0	7896 - 8455	29	7.180E-22	1.116E-26	8.091E-23	14
10922.7977	4 - 0	10649 - 11003	19	3.188E-24	1.330E-26	3.646E-25	9
13396.1869	5 - 0	13261 - 13458	12	2.276E-25	1.089E-26	3.035E-26	6

[*continued*. . .]

Table 2—*continued*

ν_o	$v' - v''$	$\nu_{min} - \nu_{max}$	#lines	ΣS	S_{min}	S_{max}	J''_{max}
Total Number of lines for the $H^{37}Cl$ (17) isotope is: 168							
	0 - 0	20 - 419	21	2.585E-18	4.419E-26	4.631E-19	20
	1 - 1	20 - 240	12	2.220E-24	1.009E-26	3.949E-25	11
2780.0426	2 - 1	2577 - 2948	19	2.382E-24	1.150E-26	2.485E-25	9
2883.8850	1 - 0	2399 - 3152	38	1.517E-18	1.223E-26	1.606E-19	19
5457.0557	3 - 1	5510 - 5526	2	2.068E-26	1.030E-26	1.038E-26	3
5663.9276	2 - 0	5194 - 5826	33	3.434E-20	3.712E-26	3.757E-21	16
8340.9407	3 - 0	7934 - 8449	27	2.288E-22	1.356E-26	2.577E-23	13
10915.3415	4 - 0	10719 - 10995	16	9.936E-25	1.498E-26	1.159E-25	8
Total Number of lines for the $H^{79}Br$ (19) isotope is: 200							
	0 - 0	16 - 383	24	2.405E-18	1.423E-26	3.946E-19	23
	1 - 1	16 - 239	15	9.921E-24	1.609E-26	1.603E-24	14
2468.4304	2 - 1	2266 - 2625	23	5.575E-24	1.037E-26	4.960E-25	11
2558.9105	1 - 0	2123 - 2791	42	7.232E-19	1.003E-26	6.526E-20	21
4846.3505	3 - 1	4889 - 4914	3	3.380E-26	1.065E-26	1.180E-26	4
5027.3408	2 - 0	4593 - 5164	36	7.909E-21	1.009E-26	7.322E-22	18
7405.2610	3 - 0	7048 - 7496	29	1.976E-22	1.457E-26	2.074E-23	14
9692.3579	4 - 0	9333 - 9759	28	1.014E-22	1.619E-26	1.045E-23	14
Total Number of lines for the $H^{81}Br$ (11) isotope is: 198							
	0 - 0	16 - 383	24	2.339E-18	1.393E-26	3.837E-19	23
	1 - 1	16 - 239	15	9.667E-24	1.571E-26	1.562E-24	14
2468.0697	2 - 1	2265 - 2625	23	5.432E-24	1.012E-26	4.832E-25	11
2558.5308	1 - 0	2147 - 2791	41	7.033E-19	1.622E-26	6.345E-20	20
4845.6620	3 - 1	4888 - 4913	3	3.293E-26	1.038E-26	1.150E-26	4
5026.6005	2 - 0	4623 - 5163	35	7.690E-21	2.356E-26	7.119E-22	17
7404.1928	3 - 0	7048 - 7495	29	1.921E-22	1.420E-26	2.016E-23	14
9690.9914	4 - 0	9332 - 9758	28	9.858E-23	1.577E-26	1.016E-23	14
Total Number of lines for the $H^{127}I$ (17) isotope is: 237							
	0 - 0	12 - 320	26	1.067E-18	3.883E-26	1.539E-19	25
	1 - 1	12 - 221	18	2.099E-23	1.316E-26	2.989E-24	17
2149.6444	2 - 1	2069 - 2272	18	8.340E-25	1.269E-26	9.778E-26	11
2229.5817	1 - 0	1950 - 2421	40	1.934E-20	1.189E-26	2.245E-21	22
4218.4531	3 - 1	4164 - 4294	9	1.396E-25	1.078E-26	2.059E-26	7
4379.2261	2 - 0	4047 - 4489	39	6.018E-21	1.328E-26	5.714E-22	20
6205.1259	4 - 1	6114 - 6267	12	1.723E-25	1.017E-26	1.960E-26	7
6448.0348	3 - 0	6032 - 6521	39	3.375E-21	1.109E-26	2.992E-22	19
8434.7076	4 - 0	8031 - 8488	36	5.571E-22	1.089E-26	4.932E-23	18
Total Number of lines for the $^{14}N_2$ (44) isotope is: 120							
2329.9117	1 - 0	1992 - 2626	120	6.719E-27	2.194E-34	3.415E-28	40
Total Number of lines for the $H_2{}^{16}O_2$ (1661) isotope is: 5,444							
	000000 - 000000	0 - 100	883	2.886E-18	1.100E-25	2.200E-20	23
1269.136	000001 - 000000	1001 - 1500	4561	1.583E-17	1.751E-24	4.464E-20	35

[*continued*...]

Table 2—*continued*

ν_o	$v' - v''$	$\nu_{min} - \nu_{max}$	#lines	ΣS	S_{min}	S_{max}	J''_{max}
Total Number of lines for the $^{12}C_2H_2$ (1221) isotope is: 1,172							
719.9658	00000200 - 00000111	640 - 805	93	9.430E-19	3.670E-23	5.290E-20	35
728.8574	00011110 - 00011001	638 - 811	198	1.439E-18	2.460E-23	3.600E-20	35
729.1365	00000222 - 00000111	655 - 820	187	1.119E-18	3.710E-23	2.610E-20	34
729.1553	00000111 - 00000000	646 - 811	182	2.383E-17	3.510E-23	1.140E-18	35
731.1074	00011112 - 00011001	650 - 822	191	1.355E-18	4.280E-23	3.330E-20	34
1328.0735	00011110 - 00000000	1192 - 1470	119	2.664E-18	1.371E-27	1.384E-19	59
3281.9020	01011110 - 00000000	3151 - 3387	101	5.004E-18	3.350E-25	2.580E-19	50
3294.8406	00100000 - 00000000	3162 - 3398	101	4.240E-18	2.830E-25	2.180E-19	50
Total Number of lines for the $H^{12}C^{13}CH$ (1231) isotope is: 86							
3284.1904	00100000 - 00000000	3178 - 3375	86	1.835E-19	1.230E-24	6.200E-21	43
Total Number of lines for the $^{12}C_2H_6$ (1221) isotope is: 4,749							
821.737	V9 - GROUND	720 - 933	4328	1.456E-18	2.000E-24	3.420E-21	
2985.39	V7 - GROUND	2973 - 3001	421	3.436E-18	1.000E-22	3.210E-20	49
Total Number of lines for the $^{12}C^{16}O^{19}F_2$ (269) isotope is: 46,894							
773.9990	000001 - 000000	725 - 825	11549	4.410E-18	4.736E-24	5.732E-21	72
963.3272	010000 - 000000	933 - 990	7234	8.850E-18	3.558E-22	4.732E-21	61
1239.4366	000020 - 000000	1210 - 1272	332	4.025E-19	2.753E-22	1.347E-20	48
1243.2661	000100 - 000000	1196 - 1286	14521	5.287E-17	2.750E-22	3.721E-20	83
1913.8423	020000 - 000000	1879 - 1969	5211	1.217E-17	5.005E-22	1.224E-20	70
1937.266	002001 - 000000	1914 - 1971	109	2.241E-19	5.262E-22	1.816E-20	67
1944.6137	100000 - 000000	1889 - 1982	7938	4.055E-17	5.005E-22	3.832E-20	70
Total Number of lines for the $^{32}S^{19}F_6$ (29) isotope is: 11,520							
948.	V3 - GROUND	940 - 953	11520	5.243E-17	2.164E-22	1.503E-20	96
Total Number of lines for the $H_2{}^{32}S$ (121) isotope is: 661							
1182.574	010 - 000	994 - 1574	661	7.959E-20	9.100E-24	1.810E-21	15

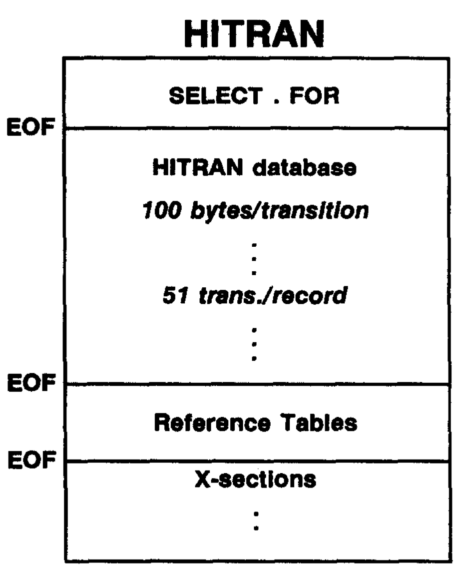

Fig. 1. File structure of compilation.

Table 3. Summary of cross-section data.

Molecule	Spectral Range (cm^{-1})	No. of Temps	Number of points per T
CCl_3F (CFC-11)	830-860	6	2 023
	1060-1107	6	3 168
CCl_2F_2 (CFC-12)	867-937	6	4 718
	1080-1177	6	6 539
$CClF_3$ (CFC-13)	765-805	6	2 696
	1065-1140	6	5 056
	1170-1235	6	4 382
$C_2Cl_3F_3$ (CFC-113)	780.5-995	6	430
	1005.5-1232	6	454
$C_2Cl_2F_4$ (CFC-114)	815-860	6	3 034
	870-960	6	6 067
	1030-1067	6	2 494
	1095-1285	6	12 808
C_2ClF_5 (CFC-115)	955-1015	6	4 044
	1110-1145	6	2 360
	1167-1259	6	6 269
N_2O_5	555.4-599.8	4	93
	720.3-764.7	4	93
	1210.1-1274.8	4	135
	1680.2-1764.6	4	176
$ClONO_2$	740-840	2	10 371
	1240-1340	2	1 400
	1680-1790	2	1 540
HNO_4	770-830	1	5 476
$CHCl_2$ (CFC-21)	785-840	1	5 020
CCl_4	786-806	1	1 826
CF_4 (CFC-14) †	1255-1290	6	2 359
$CHClF_2$ (CFC-22) †	780-1335	6	11 798
HNO_3 ‡	1270-1350	1	7 301

† Omitted from HITRAN'91, added to HITRAN'92.
‡ Removed from HITRAN'92 (already on high resolution portion).

Table 4. Error codes.

Wavenumber		Intensity and Halfwidth	
IERF	Error Range	IER(S/H)	Error Range
0	≥ 1. or Undefined	0	Undefined
1	≥ 0.1 and <1.	1	Default or Constant
2	≥ 0.01 and <0.1	2	Average or Estimate
3	≥ 0.001 and <0.01	3	≥ 20%
4	≥ 0.0001 and <0.001	4	≥ 10% and < 20%
5	≥ 0.00001 and <0.0001	5	≥ 5% and < 10%
6	< 0.00001	6	≥ 2% and < 5%
		7	≥ 1% and < 2%
		8	< 1%

Table 5. Formats for the six classes of local identification.

Group 1:	**Asymmetric Rotors.**
	H_2O, O_3, SO_2, NO_2,† HNO_3, H_2CO, HOCl, H_2O_2, COF_2, H_2S
	J′, K'_a, K'_c, F′, Sym′; J″, K''_a, K''_c, F″, Sym″
	I2, I2, I2, I2, A1 ; I2, I2, I2, I2, A1
Group 2:	**Diatomic and Linear Molecules with Integer J**
	CO_2, N_2O, CO, HF, HCl, HBr, HI, OCS, N_2, HCN, C_2H_2
	____, Br, F″, __; ____, Br, J″, Sym″
	5X, A1, I2, 1X ; 4X, A1, I3, A1
Group 3:	**Spherical Rotors**
	Methane (CH_4 only, not CH_3D)
	J′, R′, C′, N′, Sym′; J″, R″, C″, N″, Sym″
	I2, I2, A2, I2, A1 ; I2, I2, A2, I2, A1
Group 4:	**Symmetric Rotors**
	CH_3D, NH_3, CH_3Cl, C_2H_6,‡ PH_3, SF_6
	J′, K′, C′, ___, Sym′; J″, K″, C″, ___, Sym″
	I2, I2, A2, 2X, A1 ; I2, I2, A2, 2X, A1
Group 5:	**Triplet Ground Electronic States**
	O_2
	____, Br, F″, __; Br, N″, Br, J″, __, Sym″
	3X, A1, F5.4, 1X ; A1, I2, A1, I2, 2X, A1
Group 6:	**Doublet Ground Electronic States (Half Integer J)**
	NO, OH, ClO
	____, Br, F″, __; ____, Br, J″, Sym″
	5X, A1, I2, 1X ; 3X, A1, F5.4, A1

Notes: Prime and double primes refer to upper and lower states respectively; Br is the P-, Q-, or R-branch symbol; J is the rotational quantum number; Sym is e or f for ℓ-type doubling, + or - for symmetry symbols.
† For NO_2, F - J was used instead of F, see text. ‡See text.

Table 6. Example of direct image of line parameters.

Mol/ Iso	ν_o	S	$\|R\|^2$	γ_{air}	γ_{self}	E″	n	δ	v′	v″ Q′	Q″	IER	IREF
21	800.450992	3.198E-26	6.578E-05	.0676	.0818	2481.5624	.78	.000000	14	6	P 37	465	1 1 1
291	800.454690	3.242E-22	0.000E+00	.0845	.1750	369.6303	.94	.000000	9	1341519	331419	000	4 4 1
291	800.454690	9.724E-22	0.000E+00	.0845	.1750	369.6303	.94	.000000	9	1341619	331519	000	4 4 1
121	800.455380	1.037E-22	1.596E-03	.1100	.0000	530.3300	.75	.000000	32	1446 740	45 640	000	4 4 1
121	800.455380	1.037E-22	1.596E-03	.1100	.0000	530.3300	.75	.000000	32	1446 640	45 540	000	4 4 1
101	800.456932	5.190E-23	5.133E-04	.0670	.0000	851.0515	.50	.000000	2	145 244	-44 143	-301	3 3 1
121	800.457760	4.726E-23	4.446E-03	.1100	.0000	920.0900	.75	.000000	32	14502822	492722	000	4 4 1
121	800.457760	4.726E-23	4.446E-03	.1100	.0000	920.0900	.75	.000000	32	14502922	492822	000	4 4 1
24	800.465942	9.794E-27	6.064E-04	.0754	.1043	1341.2052	.69	.000000	8	3	R 13	425	1 1 1
121	800.466160	1.061E-22	2.621E-03	.1100	.0000	632.1200	.75	.000000	32	14471136	461036	000	4 4 1
121	800.466160	1.061E-22	2.621E-03	.1100	.0000	632.1200	.75	.000000	32	14471236	461136	000	4 4 1
101	800.474983	3.650E-23	3.609E-04	.0670	.0000	851.0117	.50	.000000	2	145 244	+44 143	+301	3 3 1
31	800.475500	1.680E-24	3.623E-05	.0653	.0890	1092.4340	.76	.000000	2	151 547	50 248	002	1 1 2
291	800.476220	3.199E-22	0.000E+00	.0845	.1750	361.9747	.94	.000000	9	1341520	331420	000	4 4 1
291	800.476220	9.597E-22	0.000E+00	.0845	.1750	361.9747	.94	.000000	9	1341420	331320	000	4 4 1
101	800.484407	5.320E-23	6.593E-05	.0670	.0000	106.0811	.50	.000000	2	1 8 4 4	+ 9 3 7	+301	3 3 1
121	800.485680	5.770E-23	4.232E-03	.1100	.0000	846.9900	.75	.000000	32	144544 1	4443 1	000	4 4 1
121	800.485680	5.838E-23	4.282E-03	.1100	.0000	846.9900	.75	.000000	32	144544 2	4443 2	000	4 4 1
121	800.491430	6.593E-23	4.065E-03	.1100	.0000	828.9900	.75	.000000	32	14492327	482227	000	4 4 1
121	800.491430	6.593E-23	4.065E-03	.1100	.0000	828.9900	.75	.000000	32	14492227	482127	000	4 4 1
291	800.498890	3.146E-22	0.000E+00	.0845	.1750	353.9254	.94	.000000	9	1341321	331221	000	4 4 1
291	800.498890	9.440E-22	0.000E+00	.0845	.1750	353.9254	.94	.000000	9	1341421	331321	000	4 4 1
271	800.499020	1.580E-22	0.000E+00	.1000	.0000	2092.3540	.50	.000000	19	14	2 8	000	0 0 0
271	800.499020	2.940E-23	0.000E+00	.1000	.0000	2366.1710	.50	.000000	19	14	4 9	000	0 0 0

FORMAT (I2,I1,F12.6,1P2E10.3,0P2F5.4,F10.4,F4.2,F8.6,2I3,2A9,3I1,3I2) corresponding to:

Mol	I2-	Molecule number
Iso	I1-	Isotope number (1= most abundant, 2= second most abundant, etc.)
ν_o	F12.6-	Frequency in cm^{-1}
S	E10.3-	Intensity in $cm^{-1}/(molecule\text{-}cm^{-2})$ @ 296K
$\|R\|^2$	E10.3-	Transition probability-squared in $Debye^2$
γ_{air}	F5.4-	Air-broadened halfwidth (HWHM) in cm^{-1}/atm @ 296K
γ_{self}	F5.4-	Self-broadened halfwidth (HWHM) in cm^{-1}/atm @ 296K
E″	F10.4-	Lower state energy in cm^{-1}
n	F4.2-	Coefficient of temperature dependence of air-broadened halfwidth
δ	F8.6-	Air-broadened pressure shift of line transition in cm^{-1}/atm @ 296K
v′,v″	2I3-	Upper state global quanta index, lower state global quanta index
Q′,Q″	2A9-	Upper state local quanta, lower state local quanta
IER	3I1-	Accuracy indices for frequency, intensity, and air-broadened halfwidth
IREF	3I2-	Indices for table of references corresponding to frequency, intensity, and halfwidth

The total partition sum has been calculated according to Ref. 5 and used for both the parameter R and for the part of SELECT that enables the user to alter the temperature. The method does not always provide adequate extrapolation to high temperatures for some of the species due to lack of sufficient higher energy levels in the calculation; hence use of the classical expression for computing the total partition sum may be more appropriate in such cases.

In the 1986 edition[3] a line-coupling coefficient was given in the pressure shift field for three carbon dioxide bands (no pressure shifts were implemented on that edition). In the later editions, the line-coupling has been removed (implemented nonetheless in some modeling codes) and pressure-shift parameters have been added where available. At present a parameter to model the temperature dependence of the air-broadened pressure shift has not been implemented even though studies have shown a significant variation of the shift with temperature.[6]

Finally, it should be emphasized that the intensities in HITRAN in units of cm^{-1}/(molecule $- cm^{-2}$) at 296 K are scaled by an assumed atmospheric isotopic abundance given near the end of the third file on the compilation. Contributors providing the intensity data to HITRAN are expected to re-normalize their values with this table in consideration; recent experiments[7] have shown that doing so is not a trivial matter.

We describe in the next sections, molecule-by-molecule, the modifications to HITRAN since the edition of 1986. It should be noted that the descriptions for some molecular updates are longer than others when there were no accompanying articles in this special issue; this does not necessarily reflect on the relative importance.

NEW OR MODIFIED HIGH-RESOLUTION DATA

H_2O (molecule 1)

The 1991 edition of HITRAN has seen major updates to the near-infrared and visible regions for the principal species of water vapor and to the ν_2 region of the spectrum for the species $H_2{}^{16}O$, $H_2{}^{18}O$, and $H_2{}^{17}O$. The revisions are improved calculations for the ν_2 region from Toth,[8] and experimental results for many of the shorter wavelength bands. The latter include measurements from Toth[9] from 5904 to 7965 cm^{-1}, from Mandin et al[10] for the region from 8036 to 9482 cm^{-1}, from Chevillard et al[11] for the region from 9603 to 11841 cm^{-1}, from Toth[12] for the $3\nu_3 + \nu_2$ region (11661–12741 cm^{-1}), and from Mandin et al[13] and Camy-Peyret et al[14] for the region from 13238 to 22657 cm^{-1}. The data for each of these regions are discussed below.

The data for the ν_2 region are from Toth[8] and contain two vibrational bands, ν_2 and $2\nu_2$–ν_2, for $H_2{}^{16}O$, $H_2{}^{18}O$, and $H_2{}^{17}O$ in the spectral range between 1066 and 2582 cm^{-1}. Spectra were recorded at 0.0056 cm^{-1} resolution with the Fourier transform spectrometer[15] at the McMath solar telescope facility at Kitt Peak National Observatory. Line positions and intensities were retrieved through seven orders of magnitude of intensity with accuracies of 0.0001–0.0005 cm^{-1} and to 2–15% respectively. These measurements were analyzed using a 19-term dipole-moment expansion[8] after it was found that the 8-term expansion[16] failed to reproduce the experimental data, especially for the weaker transitions. Line positions were not modeled, so for the database, empirical lower and upper state energies were used to compute the positions of 4618 transitions. Some 185 weak lines not calculated by Toth were retained from the 1986 database (the latter are labeled by zeros in the reference fields for frequency and intensity). The line intensities of medium to weak transitions are greatly improved compared to the previous data set. This improvement results from a more accurate representation of the transition dipole-moment expansion being used. In the analysis of Toth,[8] the expansion was taken to include 19 terms, where the additional 11 matrix elements were empirically determined and added to the dipole-moment expansion. In general, the line intensities have an uncertainty less than 10%. The analysis also provided line positions with an absolute accuracy of 0.0001 cm^{-1} and a more complete set of lower-state energies for the (000) and (010) states.

The 5904–7965 cm^{-1} region containing nine vibrational bands ($4\nu_2$, $\nu_1 + 2\nu_2$, $2\nu_2 + \nu_3$, $2\nu_1$, $\nu_1 + \nu_3$, $2\nu_3$, $2\nu_1 + \nu_2 - \nu_2$, $3\nu_2 + \nu_3 - \nu_2$, and $\nu_1 + \nu_2 + \nu_3 - \nu_2$) of the principal isotopic species of water vapor was measured by Toth[9] using spectra recorded at 0.011 cm^{-1} resolution with the Kitt Peak FTS. For the 1991 edition of HITRAN, 2923 medium intensity lines in the region were replaced by a preliminary tabulation of his empirical results, while 2307 very strong or very weak lines were retained from the 1986 HITRAN database. The strong lines were not yet available from Toth's study because the Kitt Peak FTS enclosure contained residual water vapor that contributed background absorption. Since these results were not yet modelled, no attempt was made to normalize the 1986 calculated intensities to Toth's results, nor to recompute the 1986 line positions. Measured accuracies of the new data are 0.0002 cm^{-1} for positions and 2–10% for the intensities.

Mandin et al[10] recorded spectra of the second hexad of interacting states of $H_2{}^{16}O$, employing the Kitt Peak FTS. This study has supplied position and intensity data for nine bands in the wavenumber range 8036–9482 cm^{-1}. Both the curve of growth of the equivalent-width method and the peak-absorption method were used to measure the line intensities. The reported line intensities are grouped as follows: for "good" lines the uncertainty is between 6 and 15%, and a mean value of 10% is given. For perturbed lines, the uncertainty is in the range 15–25%, with a mean value of 20% reported. For strong overlapping lines, a mean uncertainty of 50% is given. These data contain 1699 lines for the $5\nu_2$, $4\nu_2+\nu_3-\nu_2$, $\nu_1+3\nu_2$, $3\nu_2+\nu_3$, $\nu_1+2\nu_2+\nu_3-\nu_2$, $2\nu_1+\nu_2$, $\nu_1+\nu_2+\nu_3$, $6\nu_2$, $\nu_2+2\nu_3$ vibrational bands and an additional 175 unassigned transitions.

The data of Chevillard et al[11] covering the range from 9603 to 11841 cm^{-1} were also recorded using the FTS at Kitt Peak. Both the curve of growth of the equivalent-width method and the peak-absorption method were used to measure the line intensities. The uncertainty for well-isolated lines is between 6 and 15%, and a mean value of 10% is given. For lines that are perturbed, the uncertainty is between 15 and 25% (mean value of 20% reported). For lines that overlap, a mean uncertainty of 50% is given. There are 2413 lines of data belonging to 8 vibrational bands: $4\nu_2+\nu_3$, $2\nu_1+2\nu_2$, $\nu_1+2\nu_2+\nu_3$, $2\nu_2+2\nu_3$, $3\nu_1$, $2\nu_1+\nu_3$, $\nu_1+2\nu_3$, and $3\nu_3$. There are also 71 unassigned transitions with the position and line intensity values listed.

From 11661 to 12741 cm^{-1}, data containing the five vibrational bands $\nu_1+3\nu_2+\nu_3$, $3\nu_1+\nu_2$, $2\nu_1+\nu_2+\nu_3$, $\nu_1+\nu_2+2\nu_3$, and $\nu_2+3\nu_3$ were reported by Toth.[12] Empirical measurements were tabulated with precisions of 0.0006 cm^{-1} for positions and 10% or better for intensities. However, because of the lack of calibration standards, the absolute accuracies of the positions may be a factor of five worse. In this set, residual water vapor in the FTS was not a problem due to the weakness of the bands. The final data set consisted of 714 measurements of strong and medium intensity lines combined with 669 lines retained from the 1986 database. Again, because these data were not yet modelled, no attempt was made to normalize the 1986 intensities or to recompute the 1986 positions.

The final update to the H_2O data was in the visible region of the spectrum. The data are from Mandin et al[13] (from 13238 to 16500 cm^{-1}) and from Camy-Peyret et al[14] (from 16500 to 22657 cm^{-1}). Most of the spectra used in the analysis were recorded with the FTS[15] at the National Solar Observatory at Kitt Peak, while a few additional spectra were recorded using a grating spectrometer and a Bomem FTS at the National Research Council of Canada. Line positions and intensities were measured for 40 different vibrational bands of $H_2{}^{16}O$. The uncertainty in the line positions varies from 0.002 cm^{-1} for the strong and well-isolated lines to 0.015 cm^{-1} for the weakest ones. The line intensities were determined by the method of equivalent widths and by the peak-absorption method yielding an uncertainty in absolute intensities varying from 5 to 25% depending on the line. These data contain 3153 transitions belonging to 40 different vibrational bands of $H_2{}^{16}O$. There were also 1433 unassigned lines for this species and 2 unassigned lines for $H_2{}^{18}O$. These updates represent a total replacement of earlier grating spectrometer observations (also conducted at Kitt Peak) that were on HITRAN and also extend the wavenumber limit of HITRAN to shorter wavelength.

The only modification to water vapor parameters for the 1992 edition has been changing the lower state energies of some of the partially identified transitions between 10,100 and 11,250 cm^{-1} in order to be consistent with the HITRAN convention of $E'' = -1$. These transitions originating from the ground vibrational state have unidentified lower state rotational quanta which were inadvertently assigned a lower state energy of zero in the 1991 edition of the HITRAN database.

The 1991 edition of HITRAN incorporated many experimentally determined air- and self-broadened halfwidth values. Previous editions included only air-broadened halfwidths which were taken from theoretical calculations and an empirical algorithm. In the latest scheme, 276 air-broadened halfwidths and 261 self-broadened halfwidths from measurements[17] are given priority over the theoretical values. The observed data were combined with the theoretical calculations.[18,19]

If there was no experimental value available for a level, the theoretical value of Gamache and Davies[18] was used. If neither a measured value nor a calculated value existed on the halfwidth file, a default value for the air- or the self-broadened halfwidth as a function of J was used.[20] Thus, there remain no halfwidth values based on the empirical algorithm.

The temperature dependence of the air-broadened halfwidth is assumed in the database to follow the relationship

$$\gamma(T) = \gamma(T_0)(T_0/T)^n. \quad (1)$$

Measured and calculated air-broadened, temperature-dependence exponents, n, have been added to the corresponding rotational transitions on the database. All other transitions have the default value of $n = 0.68$ as recommended by Gamache and Rothman.[19]

CO_2 (molecule 2)

As part of a long standing program, the carbon dioxide parameters were updated on both the 1991 and 1992 HITRAN editions. The details regarding the new parameters are given in a separate article in this issue.[21]

The line positions of CO_2 transitions in these editions were obtained by using an improved least-squares fit, although there have not been many new observed levels added to the fit since the previous editions. However, as discussed in Ref. 21, the accuracy of the line positions is improved and is indicated in the error criteria column of the compilation. The most significant improvement has been in the intensities. Extensive observations in several spectral regions, especially by Johns[22] and Dana et al[23,24] have permitted an update of the dipole-moment function of the molecule. With the improved dipole-moment function, the Direct Numerical Diagonalization (DND) method[25] has been applied to the unobserved bands of the three most abundant isotopes (626, 636, and 628). DND has provided Herman–Wallis coefficients through the quadratic term; recent comparisons with experiment[26] demonstrate a high reliability for these calculations.

The air-broadened and self-broadened halfwidths, along with the temperature-dependent exponent of the air-broadened halfwidth, have been updated for the 1992 edition.[21] This update addresses a deficiency that was discussed at recent meetings.[27]

O_3 (molecule 3)

There were very significant changes of the ozone line parameters for the 1991 edition. In addition to updates of bands already on previous compilations, many new bands were added. The line positions and intensities are from the atlas of Flaud et al,[28] but with a lower intensity cutoff. Table 2 shows the extensive coverage of the parameters. For the first time the bands of $^{16}O^{16}O^{18}O$ (668) and $^{16}O^{18}O^{16}O$ (686) have been calculated based on analyses of high-resolution spectroscopic data which is a vast improvement over the earlier rough estimates that existed on HITRAN for some of the isotopic bands. Details of this work are contained in the accompanying article.[29]

For air-broadened halfwidths of ozone, the theoretical nitrogen-broadened calculations of Gamache and Rothman[30] scaled to air by multiplying by 0.95, and increased systematically as recommended by Smith et al,[31] were used. The calculations included values of the rotational quantum number J up to 35. Above this value, the air-broadened halfwidth was estimated via a polynomial in J given by Flaud et al.[32] For the self-broadened halfwidths on the database, a polynomial in J and K_a from Smith et al[33] has been utilized. Although some measurements of pressure-induced line shifts of ozone exist,[31] no values of this parameter have been included on the current compilation

CO (molecule 5)

For carbon monoxide, all data for the four isotopes (26, 36, 28, and 27) listed in the 1986 HITRAN edition have been recalculated, and data for a new isotope (38) were added. The transition frequencies calculated using the Dunham constants obtained by Guelachvili et al[34] and Pollock et al,[35] and the intensities calculated using the dipole moment of Chackerian and Tipping,[36] were not substantially changed. Other parameters, air-broadened halfwidth, self-broadened halfwidth, and the temperature dependence of the air-broadened halfwidth (γ, γ_s and n) are either new or have been changed significantly. The air-broadened halfwidths for $|m| \leqslant 20$ were taken from the experimental data of Nakazawa and Tanaka;[37] values for transitions having $20 < |m| \leqslant 33$ were extrapolated, while values for $|m| \geqslant 34$ were assumed to be constant. Both the self-broadened halfwidths and the temperature coefficient n were taken from the results of Hartmann et al.[38] At present no comprehensive data for the pressure shifts exist so the default value of zero has been employed. The number of lines and band statistics are summarized in Table 2.

CH_4 (molecule 6)

For methane, the major changes were improvements to existing entries at longer wavelength, the inclusion of new weak bands, and the addition of measured widths and shifts in all regions. New laboratory results were used in five spectral intervals: (a) 0–579 cm^{-1}; (b) 904–1969 cm^{-1}; (c) 2005–3254 cm^{-1}; (d) 3700–4667 cm^{-1}; and (e) 5500–6185 cm^{-1}. Calculations of the lower fundamentals of $^{12}CH_4$, $^{13}CH_4$ and CH_3D were revised, and 16 new hot bands from 0 to 1978 cm^{-1} were added. For $^{12}CH_4$ and $^{13}CH_4$, measured air-broadened linewidths and pressure-shifts of over 1300 transitions between 1100 and 4600 cm^{-1} were inserted, and their averaged values were extrapolated for transitions not directly measured. Finally, experimental measurements from 3700 to 3900 cm^{-1} and 5500 to 6185 cm^{-1} were included and the reference and error code fields were also implemented for the first time.

Between 1991 and 1992, the only changes were in the 3900 to 4170 cm^{-1} region with the insertion of empirical lower state energies and the addition of 456 weak lines. A lower minimum-intensity criterion was applied so that many lines weaker than $4 \times 10^{-24}\ cm^{-1}/(molecule - cm^{-2})$ were incorporated; as a result, the number of lines changed from 17,774 in 1986 to 47,427 in 1992. A separate article in this issue[39] provides the details of the methane revisions.

An error was made in converting a few of the ν_2 and ν_4 transitions of $^{12}CH_4$ and $^{13}CH_4$ into the HITRAN format in that the vibrational code v' was reversed for two dozen pairs of levels. The rotational quantum numbers J, C and n of the specific upper state levels involved are tabulated in Table 7. Those ν_4 levels shown there under $C(\nu_4)$ were incorrectly notated in the 1991 and 1992 editions as ν_2 ($v' = 3$) while the ν_2 levels listed as $C(\nu_2)$ were coded as ν_4 ($v' = 2$). For example, at $J = 6$ and $n = 2$, all the ν_4 transitions to the $C = A1$ level are notated as ν_2 while those of ν_2 with $C = A2$ are written as ν_4. As a result, the intensity statistics in Table 2 are not correct for these two bands. This error will be rectified with the next update of methane.

NO (molecule 8)

The only updates for nitric oxide for these editions have been for the intensity of the fundamental[40] and the air-broadened halfwidths[41] for all bands.

Table 7. The upper state levels of the methane dyad with incorrect vibrational codes.

J′	C(ν4)	C(ν2)	n	J′	C(ν4)	C(ν2)	n	J′	C(ν4)	C(ν2)	n
0	F2		1	8	F2	F1	7	16	F2	F1	13
1	A2		1	9	A2	A1	3	17	A2	A1	5
2	A1		1	10	A1	A2	3	18	A1	A2	5
3	F1	F2	3	11	F1	F2	9	19	F1	F2	15
4	F2	F1	4	12	F2	F1	10	20	F2	F1	16
5	A2	A1	2	13	A2	A1	4	21	A2	A1	6
6	A1	A2	2	14	A1	A2	4	22	A1	A2	6
7	F1	F2	6	15	F1	F2	12	23	F1	F2	18

Note: A few of the ν_2 and ν_4 transitions of $^{12}CH_4$ and $^{13}CH_4$ were listed with the wrong vibrational code. The rotational quantum numbers J, C and n are shown for the specific pairs of upper state levels with the correct vibrational assignment in parenthesis. For example, at J = 15 and n = 12, all the ν_4 transitions to the C equal F1 level are notated as ν_2 while those of ν_2 with C equal F2 are written as ν_4.

SO_2 (molecule 9)

The recent spectroscopic detection of atmospheric sulfur dioxide from the volcanic eruption of Mt Pinatubo has renewed interest in the line parameters of SO_2.[42,43] The 1992 HITRAN database includes updated line parameters for both the ν_3 and ν_1 fundamentals. The line positions were computed from the work of Guelachvili et al.[44,45]

The ν_3 and ν_1 band intensities of $3.080 \times 10^{-17}\,cm^{-1}/(molecule - cm^{-2})$ and $3.519 \times 10^{-18}\,cm^{-1}/(molecule - cm^{-2})$ at 296 K on the 1986 HITRAN compilation have been retained, since no clear revision could be noted based on the published papers (summarized by Smith et al[46]).

The most significant difference in comparison with the SO_2 lines of the 1986 HITRAN database is a discrepancy of approximately $0.031\,cm^{-1}$ found for the ν_3 lines. The new line positions are accurate to $0.001\,cm^{-1}$. For the ν_1 lines, the line positions are within $0.003\,cm^{-1}$ of the values on the 1986 HITRAN compilation.

As a first approximation, a constant air-broadening coefficient of 0.12 and $0.13\,cm^{-1}/atm$ at 296 K for the ν_3 and ν_1 bands, respectively, was adopted. Corresponding self-broadening values of 0.40 and $0.39\,cm^{-1}/atm$ have been incorporated. These values are based on averages of measurements of Hinkley et al[47] and the theoretical calculations of Tejwani.[48,49] The calculations of Tejwani[48,49] and recent tunable diode laser measurements by Kuhnemann et al,[50] indicate that the air-broadening coefficients generally decline with increasing J-quantum number; this effect should be incorporated in future compilations.

NO_2 (molecule 10)

The changes for nitrogen dioxide were made on the 1992 edition. These modifications included a total replacement of the ν_2 region[51] and the pure rotation bands.[52,53] In the pure rotation region, the hot band (010 – 010) was also added. Furthermore, an effort was undertaken to make all the lower state energies consistent. The zero of energy was chosen for the state $v = 000$, $N = 0$, $K_a = 0$, $K_c = 0$, $J = \frac{1}{2}$, and $F = \frac{1}{2}$, and all the lower state energies (E'') of the NO_2 molecule were adjusted accordingly. The symmetry symbols were defined on this edition of the database as necessary for an unambiguous description. Considered under group 1 of Table 5, the local quanta fields are given by N, K_a, K_c, $(F - J)$, and symmetry of J. For symmetry of J, a plus sign (+) designates $J = N + \frac{1}{2}$ and a minus sign (−) designates $N - \frac{1}{2}$. The field with $(F - J)$ takes on the three possible values 1, 0, and −1.

The halfwidths were also updated[54] for all bands of nitrogen dioxide to the value $0.067\,cm^{-1}/atm$. Further details of the new parameters, as well as future developments can be found in the accompanying article in this issue.[55]

HNO_3 (molecule 12)

A significant update of the nitric acid line parameters has been accomplished for the 1991 HITRAN compilation, with no further update for the 1992 edition. While the ν_5 and $2\nu_9$ bands are retained from the 1986 compilation, new line parameters are provided for eight bands: ν_6, ν_7, ν_8, ν_9, $\nu_8 + \nu_9$, ν_3, ν_4, and ν_2 derived from Maki and Olson,[56] Goldman et al,[57] Maki,[58] Perrin et al,[59] Maki,[60] and Goldman et al.[61]

Based on the work of May and Webster,[62] air-broadened and self-broadened halfwidths were set for all HNO_3 transitions throughout the database to 0.11 and $0.73\,cm^{-1}/atm$ respectively, while the temperature-dependent coefficient was set to 0.75.

A more detailed discussion of the updated nitric acid line parameters is given in the separate paper in this issue by Goldman and Rinsland.[63]

Hydrogen halides

Analogous to the case of carbon monoxide, all the data for the hydrogen halides have been revised and/or extended. For the most part, this enhancement has resulted in only slight adjustments in the transition frequencies and intensities, although improved intensity data for several molecules have been incorporated. Moreover, for all of the hydrogen halides the intensity cutoff has been lowered to $1.00 \times 10^{-26}\,cm^{-1}/(molecule - cm^{-2})$, resulting in a modest increase in the number of lines. However, some higher overtones of the hydrogen halides and transitions of the deuterated species are not included, even though they have intensities that exceed the intensity cutoff.

For the most part, the self- and air-broadened halfwidths have been implemented, although some of the values have been obtained by extrapolation or by temperature scaling. Except for HF and HCl, no data on the temperature coefficient or pressure shifts exist; these parameters have been assigned default values (0.5 for the temperature dependence and 0 for the pressure shift). The sources for the data in the current edition are given below.

HF (molecule 14)

The frequencies of the pure rotational band were calculated from the data of Jennings et al,[64] while those for $\Delta v = 1$ and the overtone bands were from the data of Guelachvili.[65] The intensities were recalculated using a dipole-moment function similar to that published recently by Zemke et al.[66] The air-broadened halfwidths were obtained from the following sources: for the pure rotation band, the data of Bachet[67] were used, while for the fundamental band those of Pine and Looney[68] were adopted. For the overtone bands, the data of Meredith and Smith[69] obtained at $T = 373$ K for N_2-broadening were scaled to $T = 296$ K using $n = 0.5$ (despite the large variation of n observed in the fundamental for air broadening) and then scaled to air broadening assuming $\gamma = 0.9\,\gamma_{N_2}$.

For the self-broadened halfwidths, as no data exist for the pure rotational band, the default value of zero was adopted. For the fundamental band, the data of Pine and Fried were adopted,[70] while for the overtone bands the data of Meredith,[71] scaled from 373 to 296 K using a mean temperature-dependence exponent $n = 0.5$ were assumed. For the fundamental band, the values of n and the pressure shift δ, given by Pine and Looney[68] were adopted; for the pure rotational band, the shifts for a few transitions having low quantum numbers J given by Bachet and Coulon[72] were used, whereas values for transitions having higher J were obtained by extrapolation similar to that observed in the fundamental band.

HCl (molecule 15)

The frequencies for all transitions of hydrogen chloride were calculated assuming the parameters obtained by Coxon and Ogilvie[73] who made a global fit of existing spectral data. Similarly, the intensities were calculated using the dipole-moment function given by Ogilvie et al,[74] modified slightly to incorporate the more recent measurements of Pine et al.[75] For the air-broadened halfwidths, the data of Pourcin et al[76] for $\Delta v = 0$ transitions were assumed, while those of Pine and Fried[70] were assumed for all the vibrational bands. The following sources of data were used for the self-broadened halfwidths: Sergent-Rozey et al[77] for $\Delta v = 0$ transitions, Pine and Looney[68] for $\Delta v = 1$ and 2 transitions, and Stanton and Silver[78] for $\Delta v = 3$ transitions. For the temperature coefficient, almost identical values for the fundamental transitions have been published by Chackerian et al[79] and by Pine and Looney;[68] the data of the latter authors were used. No data are available for other bands. Finally, for shifts, only the data from Pine and Looney[68] for the fundamental and from Guelachvili and Smith[80] for the overtone band are available.

HBr (molecule 16)

The frequencies for all transitions included for hydrogen bromide were calculated from the Dunham parameters published by Bernage and Niay,[81] and the results are similar to those appearing in the previous edition of HITRAN. The intensities were recalculated based on an improved dipole-moment function obtained by Carlisle et al.[82] No experimental data exist for the air-broadened halfwidths, and the values adopted are the same as those in the previous edition. For the self-broadened halfwidths, the data for low-J transitions published by Séoudi et al[83] were used; values for $|m| > 12$ were extrapolated, and it was assumed that there is no vibrational dependence for this parameter. While this assumption is not strictly true, the values obtained are felt to be reasonable based on trends observed in the more complete datasets for HF and HCl. No data for n or δ exist and these have been set to their default values of 0.5 and 0 respectively.

HI (molecule 17)

For hydrogen iodide, the frequencies for all transitions included in HITRAN were calculated using the Dunham parameters of Guelachvili et al.[84] New intensities were calculated based on the recent intensity measurements of Riris et al.[85] For γ, no data exist and the default value of 0.05 was assumed. Self-broadened halfwidths were obtained from the work of Ameer and Benesch[86] and Niay et al,[87] where, as in the case of HBr, no vibrational dependence was included. Again as for HBr, no data exist for either n or δ, and the default values of 0.5 and 0 were used.

OCS (molecule 19)

The only change for carbonyl sulfide since the 1986 HITRAN has been the update of the air-broadened halfwidths using a polynomial fit to the data of Bouanich et al.[88] Recent improvements for this species have not been incorporated into HITRAN, and this situation will be remedied on future editions.

N_2 (molecule 22)

The $(1-0)$ vibration–rotation quadrupole band of nitrogen at 2329.9117 cm^{-1} is the only band of molecular nitrogen on the HITRAN database. A partial update of this band was performed for the 1991 compilation, followed by a more complete update of the parameters for the 1992 edition. See the accompanying paper by Rinsland et al[89] for the description of the changes.

H_2O_2 (molecule 25)

The ν_6 band of hydrogen peroxide was updated for the 1991 edition using the work of Hillman et al[90] for the positions and the efforts cited in Ref. 91 for the intensities. However, it was subsequently discovered that the overall band intensity needed renormalization.[92] This scaling has been accomplished for the 1992 edition.

Halfwidths were updated based on the work of Devi et al.[93]

C_2H_2 (molecule 26)

The $(\nu_4+\nu_5)^0$ combination band of acetylene at 1328.0735 cm^{-1} has been added to the 1991 compilation. The positions have been calculated from the molecular constants reported in Table 1 of the work by Palmer et al[94] and the intensities have been computed from the experimental R-branch line intensities measured by Podolske et al[95] with a tunable diode laser system. The F factor has been assumed to be unity. The air- and self-broadening coefficients are the same as those adopted for the other seven acetylene bands. The parameters for these other bands have not been updated for the 1991 and 1992 editions.

C_2H_6 (molecule 27)

A set of line parameters for the Q-sub-branches of the ν_7 band of ethane, which have been observed in atmospheric spectra,[96] are included for the first time in the 1992 HITRAN database. The details of the computations are given by Goldman et al.[97] The line parameters cover the range of 2973–3001 cm^{-1}, with total intensity of $3.435 \times 10^{-18}\ cm^{-1}/(molecule - cm^{-2})$, and a constant air-broadening coefficient of 0.075 cm^{-1}/atm. Comparisons with high-resolution laboratory spectra[98] show that further improvements are needed for both line positions and intensities.

It has been observed that in the listing of the ν_9 band of ethane, a part of the rotational quantum numbers has accidentally been truncated. This is reflected in Table 2 where no maximum value of J'' is given. In addition, the values of E'' for this band are erroneous. The band has not been updated for some time, and while the frequency values are reasonably good, the intensities may be larger by a factor of 2 compared to the GEISA compilation.[99]

COF_2 (molecule 29)

Carbonyl fluoride has been detected in the stratosphere based on the measurements of absorption features of the ν_6 (774 cm^{-1}), ν_4 (1243 cm^{-1}) and ν_1 (1945 cm^{-1}) bands in the *ATMOS/Spacelab 3* spectra.[100] Subsequent balloon-borne measurements at 0.003-cm^{-1} resolution have revealed additional details of the atmospheric absorption by these bands.[101,102] Features of the ν_4 and ν_1 bands have also been observed in high-resolution ground-based solar spectra.[102]

The 1991 HITRAN compilation contains line parameters for the ν_6 band, the weak ν_2 band at 963 cm^{-1}, and a portion of the ν_4 band. Updated parameters for the ν_6 and ν_4 bands[103,104] are included on the 1992 HITRAN compilation, as well as a calculation of the ν_1 region provided by

Brown and Cohen.[105] Constant values of 0.0845 and 0.175 cm^{-1}/atm at 296 K for the air- and self-broadening coefficients and a value of 0.94 for the air-broadening temperature exponent n have been adopted on the 1992 HITRAN compilation based on the recent tunable diode laser laboratory measurements of May.[106] For additional details, see the accompanying papers by Rinsland et al[89] and May.[106]

SF_6 (molecule 30)

The spectroscopic detection of sulfur hexafluoride in the lower stratosphere and upper troposphere was recently reported based on the *ATMOS/Spacelab 3* solar occultation spectra.[107] These spectra show the unresolved Q branch of the intense ν_3 band, which is located at 947.94 cm^{-1}. The same feature has also been identified in high-resolution ground-based solar spectra recorded from high-altitude sites.[108] The ν_3 band is about 16 times stronger than the ν_4 band, which is the only other infrared-active fundamental.

The SF_6 ν_3 band has been added to the 1991 HITRAN database based on the work of Bobin et al[109] with the relative intensities normalized assuming the band intensity measured by Schatz and Hornig.[110] The average air-broadening coefficient of 0.05 cm^{-1}/atm at 300 K calculated by Tejwani and Fox[111] has been assumed for all lines along with a $T^{-0.65}$ temperature dependence derived from the same set of calculations.[111] See the accompanying paper[89] for a more detailed description of the SF_6 line parameters.

H_2S (molecule 31)

No hydrogen sulfide line parameters were included in previous editions of the HITRAN database. However, in view of the growing interest in volcanic gases, more H_2S transitions will be included in future editions.

The $H_2{}^{32}S$ (95.0% abundance) ν_2 band line parameters included in HITRAN 1992 are from the 1984 GEISA compilation by Husson et al.[99] They are based on the work of Goldman and Gillis,[112] and have not been updated since that time. The Hamiltonian constants are from Lane et al.[113,114] The strong vibration–rotation interaction affecting ν_2 intensities has been accounted for using the first-order F-factor formulation of Ben-Aryeh.[115] Intensities were based on the measured line intensities of Strow,[116] for a total of 7.959×10^{-20} cm^{-1}/(molecule $-$ cm^{-2}) at 296 K.

Pure rotation H_2S line parameters are also available in the 1984 GEISA compilation[99] based on the work of Flaud et al,[117] but were not included here.

CROSS-SECTION DATA

The chlorofluorocarbons (CFCs) and oxides of nitrogen are examples of species exhibiting dense spectra that have so far, with a few exceptions, eluded representation in the discrete parameterized format used for the molecules shown in Table 1. The approach taken in HITRAN has been to provide cross-sections for several molecular bands derived from high-resolution experimental data. The cross-sections σ are given in units of cm^2/molecule corresponding to transmittance of $\exp(-\sigma\eta)$, where η is the gas-column density (molecule/cm^2). The latest database has many of the important bands observed at six different temperatures that span representative values for the earth's atmosphere (see Table 3). The latest generation of line-by-line codes, such as FASCODE3,[118] make use of this information and can produce quantitative simulations of atmospheric profiles. Future refinements will include data at representative pressures. It is likely that line-coupling effects will also be of interest for the heavy molecules. The cross-sections for the HITRAN91/92 compilation are described in detail in a separate paper in this issue.[119] This effort represented a major improvement for HITRAN with the addition of temperature-dependent cross-sections for the chlorofluorocarbons CFC-11, CFC-12, CFC-13, CFC-14, CFC-22, CFC-113, CFC-114, and CFC-115.[119,120] For the new edition of HITRAN, new bands of nitrogen pentoxide (N_2O_5) provided by Cantrell et al[121] and chlorine nitrate ($ClONO_2$) provided by Ballard et al[122] complete the sets as shown in Table 3.

The omission of two sets of cross-sections (CFC-22 and CFC-14) in the '91 edition was corrected in the '92 edition. However, it has been discovered that the CFC-22, 780–840 cm^{-1} data set at 293 K is inadvertently repeated twice in the '92 edition.

CONCLUSION

HITRAN is continually evolving to better meet the requirements of a diverse group of users: remote sensing of the atmosphere, planetary atmospheres, energetically disturbed atmospheres, combustion processes, detection of radiant sources through the intervening atmosphere, pollution monitoring, and global climate change monitoring. As new instruments in different spectral regions become operational, HITRAN endeavors to provide the parameters necessary for these tasks. Recently, error criteria have been added to HITRAN. It is hoped that sensitivity studies will be made to better show the effects of the errors on particular simulations.

The current version of the database is available on both floppy diskettes in compressed form and CD-ROM disks (formerly the databases were available only on large magnetic tape). The direction is clearly for PC orientation. More powerful tools will be made available to the user to rapidly access subsets of data, plot data, and perform various preliminary analyses. Supplemental sets of molecular data will also become accessible.

One must emphasize that the HITRAN project is the result of the efforts of many researchers throughout the world. The megabytes of data result from the often thankless work of numerous spectroscopists analyzing, identifying, calculating, and painstakingly measuring thousands of spectral lines in laboratories and in the field.

The HITRAN92 database can be obtained on magnetic tape from the National Climatic Center of NOAA, Federal Building Asheville, NC 28801-2696. It is available on floppy diskettes for use on MS-DOS machines from Professor Dennis Killinger, Dept. of Physics, University of South Florida, Tampa, FL 33620. A version on CD-ROM optical disk can be obtained from the first author.

Note added in proof

It has been discovered that the transition frequencies and initial state energies for HCl are incorrect because of an incorrect sign for the Dunham coefficient Y_{22} used as input data by one of the authors [RHT]. The discrepancies only become significant as v and/or J increase; for example, the positions of the $J'' = 13$ lines of the HCl fundamental are in error by a few hundredths of a reciprocal centimeter. In addition, the transition frequency of the $R(9)$ line for the fundamental of HF should read 4279.9604 cm^{-1}, *not* 4279.9640 cm^{-1}. A corrected version of the data of HF and HCl has been prepared and will be made available to interested users of the HITRAN database, prior to revision on the next version.

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