JOURNAL OF MOLECULAR SPECTROSCOPY 172, 243–253 (1995)

The Second Decade of $H_2{}^{18}O$: Line Positions and Energy Levels

A. BYKOV,* O. NAUMENKO,* T. PETROVA,* A. SCHERBAKOV,* L. SINITSA,* J.-Y. MANDIN,† C. CAMY-PEYRET,† AND J.-M. FLAUD†

* *Institute of Atmospheric Optics, Siberian Branch, Russian Academy of Science, Tomsk, 634055, Russia; and* † *Laboratoire de Physique Moléculaire et Applications, CNRS, Université Pierre et Marie Curie, Bte 76, Tour 13, 4 Place Jussieu, 75252 Paris Cedex 05, France*

Spectra of ^{18}O-enriched water vapor have been recorded between 11 300 and 13 600 cm^{-1} by means of Fourier-transform spectroscopy. The analysis has led to the determination for the first time of accurate values of the rotational energy levels of the interacting vibrational states (131), (211), (013), (230), (112), and (310) which belong to the second decade of $H_2{}^{18}O$. © 1995 Academic Press, Inc.

I. INTRODUCTION

The purpose of the work is, besides atmospheric applications, the understanding of highly excited vibrational states of a light asymmetric top molecule. The $H_2{}^{18}O$ absorption has been recently investigated between 5900 and 8800 cm^{-1} (*1*), covering the $2\nu + \delta$ spectral region and between 9500 and 11 500 cm^{-1} (*2*), covering the 3ν spectral region, where ν is a quantum of the stretching vibration and δ is a quantum of the bending vibration. We present here a study of the $3\nu + \delta$ region between 11 300 and 13 600 cm^{-1} which corresponds, to our knowledge, to the highest studied excited vibrational states of $H_2{}^{18}O$.

The analysis of the spectrum has allowed us to determine accurate rotational energy levels for the six highly excited states (see Table I) (131), (211), (013), (230), (112), and (310) which belong to the second decade of interacting states of $H_2{}^{18}O$.

II. EXPERIMENTAL DETAILS

The experimental details and data reduction have previously been discussed (*2, 3*), so only the details relevant to the present study are given. The spectrum was recorded at the National Solar Observatory (Kitt Peak, AZ) using the McMath Fourier transform spectrometer. The unapodized resolution was 0.012 cm^{-1}. The water vapor was contained in a 6-m-long White-type cell allowing an absorption path length of 434 m. The sample used contained ^{18}O water at 73% concentration and also HDO and ^{17}O isotopic variants as impurities but with contents less than 1.5%. The rest of the gas was $H_2{}^{16}O$. A natural water vapor spectrum was also recorded in order to assign easily the lines of the $H_2{}^{16}O$ isotopic species. The uncertainty in the line positions is estimated to be typically 10^{-3} cm^{-1}, varying from 0.1×10^{-3} cm^{-1} for strong and well-isolated lines to 5×10^{-3} cm^{-1} for the weakest ones. In the 11 300 to 12 700 cm^{-1} spectral range, 1445 lines were found with peak absorptions ranging from 0.007 to 0.975. Among them a comparison with natural water spectrum shows that about 450 lines belong to $H_2{}^{16}O$.

0022-2852/95 $12.00

TABLE I

Observed Absorption Bands of $H_2{}^{18}O$ in the 0.8 μm Region

VIB	N	INT	Spectral range cm-1		Imin	Imax
131	110	0.00377	11600.0	12325.9	0.69	50.0
211	277	0.11510	11778.8	12633.4	0.69	424.5
013	131	0.00752	12293.4	12695.5	0.80	24.9
230	19	0.00022	11618.2	11865.6	0.69	1.7
310	100	0.00757	11796.9	12395.5	0.80	143.3
112	128	0.00414	12119.2	12633.9	0.80	12.5

Note. VIB, vibrational assignment of the upper state; N, number of assigned lines; INT, sum of the intensities of the individual assigned lines in $cm^{-2} \cdot atm^{-1}$; and I min and I max, minimum and maximum observed line intensities in 10^{-5} $cm^{-2} \cdot atm^{-1}$.

III. ANALYSIS AND RESULTS

Twelve resonating vibrational states are involved in the studied spectral region: 10 states form the so-called second decade of the water molecule which includes the interacting states {(070), (051), (150), (230), (131), (032), (310), (211), (112), (013)}, and 2 vibrational states (080) and (160) which belong to the first pentadecade. During the study, the levels of 6 vibrational states have been observed; the $7\nu_2$, $5\nu_2 + \nu_3$, $\nu_1 + 5\nu_2$, $3\nu_2 + 2\nu_3$, $8\nu_2$, and $\nu_1 + 6\nu_2$ bands were so weak that they could not be observed.

A special approach was used for the identification of the other weak bands because it is difficult to find two or more lines sharing the same upper level. There is then no confirmation of assignments by the observation of combination differences. The line assignment process was performed in parallel with the fitting of the rotational constants to obtain better predicted line positions and relative strengths. Such a procedure indeed often permits the identification of weak lines which cannot be assigned by the usual combination difference methods.

The positions and assignments of the observed lines are listed in Table II and from these lines, the energy levels reported in Table III together with their uncertainties were derived. It is worth noting that for the very weak $2\nu_1 + 3\nu_2$ band only 10 levels were determined (3 are determined from only one line each).

The $H_2{}^{18}O$ spectrum in this region is complicated by numerous resonances. In total, 23 resonance terms are needed to explain the spectrum. The following comments can be made:

A. Strong perturbations of line positions and intensities were observed for the $2\nu_1 + \nu_2 + \nu_3$ band which is the strongest band in this region:

1. There is a strong Coriolis resonance coupling the levels of the (211) and (310) states which appears for small rotational quantum numbers ($J = 2$) and the mixing coefficients reach 20–35%. Typical examples are the interaction of the (211) [826] level at 13 066.4103 cm^{-1} with the (310) [818] level at 13 071.9954 cm^{-1} (the mixing coefficients are 69 and 23%, respectively) and the interaction of (211) [716] at 12 794.1485 cm^{-1} with (310) [726] at 12 788.3330 cm^{-1} (the mixing coefficients are 82 and 11%).

2. There is a strong Fermi resonance coupling the levels of the (131) state with those of (211) beginning at small rotational quantum numbers. For example, the

TABLE II

List of the Experimental Absorption Lines of $H_2{}^{18}O$ between 11 300 and 13 600 cm^{-1}

Sigma,cm-1	Depth,%	VIB	J'	Ka'	Kc'	J''	Ka''	Kc''
11305.0772	0.0080							
11315.9097	0.0220							
11318.3153	0.0100							
11319.4771	0.0100							
11328.8793	0.0070							
11337.8504	0.0060							
11338.1359	0.0070							
11347.0760	0.0150							
11373.8592	0.0100							
11383.5537	0.0060							
11404.8532	0.0070							
11573.0549	0.0070							
11584.4905	0.0080							
11600.0769	0.0140	131	7	1	7	8	1	8
11604.4331	0.0100							
11608.1455	0.0060							
11618.2302	0.0070	230	3	1	2	4	2	3
11623.0648	0.0110	131	6	2	4	7	2	5
11623.4289	0.0200	131	6	0	6	7	0	7
11625.0259	0.0090							
11625.0547	0.0080							
11625.2751	0.0090	131	6	1	6	7	1	7
11625.3499	0.0070	230	2	2	1	3	3	0
11625.3499	0.0070	230	4	0	4	5	1	5
11626.2035	0.0140	131	6	1	5	7	1	6
11634.2714	0.0130	230	4	1	4	5	0	5
11643.5842	0.0150	131	5	1	4	6	1	5
11643.5842	0.0150	230	3	0	3	4	1	4
11646.2456	0.0110	131	5	0	5	6	0	6
11649.5563	0.0270	131	5	1	5	6	1	6
11656.6193	0.0080	131	6	3	3	7	3	4
11660.0746	0.0240	131	4	1	3	5	1	4
11660.9118	0.0080	230	2	0	2	3	1	3
11661.1937	0.0090							
11667.3359	0.0380	131	4	0	4	5	0	5
11667.9130	0.0210	131	5	2	4	6	2	5
11670.2319	0.0120	230	4	2	3	5	1	4
11673.0857	0.0150	131	4	1	4	5	1	5
11674.1875	0.0070							
11674.4511	0.0210	131	4	2	2	5	2	3
11678.5521	0.0110	230	1	0	1	2	1	2
11681.8472	0.0150	131	3	1	2	4	1	3
11684.7381	0.0120	230	2	1	2	3	0	3
11687.0973	0.0190	131	3	0	3	4	0	4
11690.8395	0.0110	131	4	2	3	5	2	4
11694.5252	0.0090	230	3	0	3	3	1	2
11696.0577	0.0480	131	3	1	3	4	1	4
11696.9879	0.0090							
11679.8735	0.0090							
11699.9032	0.0180	131	5	3	3	6	3	4
11703.9917	0.0140	131	3	2	1	4	2	2
11704.3003	0.0070							
11705.9112	0.0430	131	2	1	1	3	1	2
11706.8079	0.0510	131	2	0	2	3	0	3
11714.4896	0.0350	131	3	2	2	4	2	3
11715.5156	0.0100	230	1	0	1	1	1	0
11718.6960	0.0180	131	2	1	2	3	1	3
11721.8438	0.0190	131	4	3	1	5	3	2
11726.0844	0.0080	131	4	3	2	5	3	3
11727.9864	0.0180	131	1	0	1	2	0	2
11731.4684	0.0140	131	1	1	0	2	1	1
11733.7526	0.0270	131	2	2	0	3	2	1
11734.3588	0.0180							
11738.6726	0.0110	131	2	2	1	3	2	2
11741.0742	0.0370	131	1	1	1	2	1	2
11747.0027	0.0110	131	3	1	3	3	1	2
11749.1292	0.0110	131	5	4	2	6	4	3
11750.9536	0.0290	131	0	0	0	1	0	1
11751.1110	0.0080	131	3	3	0	4	3	1
11752.3836	0.0200	131	3	3	1	4	3	2
11763.5348	0.0110	230	1	1	0	1	0	1
11765.4722	0.0070	131	2	1	2	2	1	1
11766.3722	0.0080							
11772.9133	0.0100							
11773.2080	0.0080	131	5	2	4	5	2	3
11776.4198	0.0120	131	4	4	0	5	4	1
11778.0393	0.0420	131	1	1	1	1	1	0
11778.8133	0.0060	211	12	0	12	13	0	13
11778.8133	0.0060	211	12	1	12	13	1	13
11780.5090	0.0150	131	6	5	1	7	5	2
11780.5090	0.0150	230	3	1	2	3	0	3
11789.5101	0.0140	131	1	1	0	1	1	1
11796.9948	0.0070	310	6	2	5	7	3	4
11797.3197	0.0090	230	2	1	2	1	0	1
11797.9151	0.0110	131	1	0	1	0	0	0
11799.8058	0.0250	131	2	1	1	2	1	2
11802.3127	0.0360	131	3	2	2	3	2	1
11808.6443	0.0240	131	2	2	1	2	2	0
11809.0009	0.0100	230	4	0	4	3	1	3
11810.8977	0.0220	211	11	0	11	12	0	12
11810.8977	0.0220	211	11	1	11	12	1	12
11810.9460	0.0100							
11811.0757	0.0740	131	2	2	0	2	2	1
11813.6995	0.0130	131	3	2	1	3	2	2
11819.3890	0.0530	131	2	0	2	1	0	1
11820.7483	0.0060	211	10	2	8	11	2	9
11820.9913	0.0170	131	4	2	2	4	2	3
11821.9796	0.0090	230	4	1	4	3	0	3
11823.5152	0.0140	131	2	1	2	1	1	1
11827.5339	0.0070							
11828.6583	0.0060	131	6	3	4	6	3	3
11828.6583	0.0060	230	2	2	1	2	1	2
11836.7724	0.0400	131	2	1	1	1	1	0
11838.4075	0.0240	131	3	0	3	2	0	2
11839.5570	0.0180	131	5	3	3	5	3	2
11840.8967	0.0610	131	3	1	3	2	1	2
11841.8343	0.0420	211	10	0	10	11	0	11
11842.0037	0.0100	211	9	4	6	10	4	7
11842.7351	0.0080	211	5	1	4	6	3	3
11844.7597	0.0100	230	4	2	3	4	1	4
11845.9788	0.0150	131	4	3	2	4	3	1
11847.7673	0.0210	211	9	3	7	10	3	8
11848.0745	0.0080							
11848.2814	0.0440	131	4	3	1	4	3	2
11849.3699	0.0840	131	3	3	1	3	3	0
11849.7155	0.0320	131	3	3	0	3	3	1
11850.7911	0.0100	131	6	3	3	6	3	4
11855.0457	0.0610	131	4	0	4	3	0	3
11855.4580	0.0320	211	8	3	5	9	3	6
11856.7365	0.0230	131	4	1	4	3	1	3
11859.7104	0.0100							
11859.8454	0.0380	211	9	2	8	10	2	9
11860.2554	0.0150	211	9	1	8	10	1	9
11861.8585	0.0250	131	3	1	2	2	1	1
11862.0432	0.0210	211	8	4	4	9	4	5
11862.6916	0.0140							
11865.6288	0.0100	230	2	2	1	1	1	0
11868.2114	0.0460	211	8	2	6	9	2	7
11869.8573	0.0230	131	5	0	5	4	0	4
11871.0739	0.0560	131	5	1	5	4	1	4
11871.3534	0.0340	211	9	0	9	10	0	10
11872.0943	0.0940	211	9	1	9	10	1	10
11872.8190	0.0110	211	3	1	3	4	3	2
11874.1773	0.0110	211	8	5	3	9	5	4
11876.5176	0.0200	211	8	3	6	9	3	7
11877.1335	0.0120							
11877.3296	0.0230	211	4	1	3	5	3	2
11879.6346	0.0410	131	3	2	2	2	2	1
11882.4204	0.0190	211	4	0	4	5	2	3
11883.1605	0.0450	131	6	0	6	5	0	5
11883.4695	0.0070	310	8	3	6	9	2	7
11883.6731	0.0150	131	3	2	1	2	2	0
11884.0443	0.0170	131	6	1	6	5	1	5
11885.5534	0.0620	131	4	1	3	3	1	2
11885.7659	0.0100							
11887.0661	0.0880	211	8	1	7	9	1	8
11887.3601	0.0340	211	8	2	7	9	2	8
11887.5539	0.0080							
11887.7099	0.0320	211	7	3	4	8	3	5
11889.7462	0.0110	131	6	4	3	6	4	2
11891.7999	0.0200							
11892.6706	0.0200	131	6	4	2	6	4	3
11894.1355	0.0420	211	7	2	5	8	2	6
11895.0376	0.0140	131	7	0	7	6	0	6
11895.3682	0.0370	131	5	4	2	5	4	1
11895.7291	0.0330	131	7	1	7	6	1	6
11895.8382	0.0140	131	5	4	1	5	4	2
11896.4258	0.0070							
11897.3596	0.0180	211	7	4	3	8	4	4
11898.5176	0.0260	131	4	4	1	4	4	0
11898.5692	0.0730	131	4	4	0	4	4	1
11900.2695	0.0780	211	8	1	8	9	1	9
11901.3276	0.1850	211	8	0	8	9	0	9
11903.0180	0.0520	211	7	4	4	8	4	5
11904.8769	0.1060	211	7	3	5	8	3	6
11906.4198	0.0120							
11906.8250	0.0100	211	7	5	2	8	5	3
11906.8965	0.0080	310	3	3	0	4	4	1

Note. Sigma, wavenumber in cm^{-1}; Depth, peak absorption in %; VIB, vibrational assignment of the upper state of the transition; and J', K'_a, K'_c and J'', K''_a, K''_c, upper and lower rotational assignments of the transition.

TABLE II—*Continued*

Sigma,cm-1	Depth,%	VIB	J'	Ka'	Kc'	J''	Ka''	Kc''
11907.4852	0.0250	211	7	5	3	8	5	4
11908.7302	0.0100							
11908.8133	0.0530	131	4	2	2	3	2	1
11909.4783	0.0180	131	7	3	5	8	1	8
11909.7126	0.0100							
11913.8218	0.1750	211	7	2	6	8	2	7
11914.6539	0.0480	211	7	1	6	8	1	7
11917.2342	0.0100	211	7	6	2	8	6	3
11917.6775	0.0080							
11919.2612	0.0110							
11919.7445	0.0470	131	5	2	4	4	2	3
11920.8491	0.1750	211	6	3	3	7	3	4
11921.0892	0.2440	211	6	2	4	7	2	5
11923.7156	0.0070							
11927.2392	0.0120	211	2	1	1	3	3	0
11927.8567	0.0160							
11928.4097	0.1340	211	7	0	7	8	0	8
11928.7716	0.3420	211	7	1	7	8	1	8
11929.5358	0.0330	131	6	1	5	5	1	4
11929.7455	0.0140	131	7	4	4	8	2	7
11930.9920	0.0970	211	6	4	2	7	4	3
11932.8207	0.0150	211	3	0	3	4	2	2
11933.4557	0.0680	211	6	3	4	7	3	5
11933.5271	0.0340	211	6	4	3	7	4	4
11933.5271	0.0340	131	5	2	3	4	2	2
11933.6821	0.0160							
11934.8501	0.1940	310	6	2	5	7	1	6
11935.3371	0.0350	131	6	4	3	7	2	6
11935.6747	0.0120	211	8	0	8	8	2	7
11938.0567	0.0390	131	6	2	5	5	2	4
11938.0567	0.0390	211	6	5	1	7	5	2
11938.2497	0.0180	211	6	5	2	7	5	3
11938.4926	0.0090							
11940.1911	0.1900	211	6	1	5	7	1	6
11940.5541	0.0090							
11942.9907	0.1020	211	6	2	5	7	2	6
11944.2111	0.0120	310	6	0	6	7	1	7
11944.5808	0.0110	131	4	3	2	3	3	1
11944.8799	0.0330	310	6	1	6	7	0	7
11945.2671	0.0300	131	4	3	1	3	3	0
11947.0477	0.0140	211	6	6	1	7	6	2
11947.0477	0.0140	211	6	6	0	7	6	1
11949.5033	0.1680	211	5	2	3	6	2	4
11949.7118	0.0130	131	5	4	2	6	2	5
11951.6262	0.0150	131	6	5	1	6	5	2
11951.6262	0.0150	131	6	5	2	6	5	1
11954.0948	0.0550	131	5	5	1	5	5	0
11954.0948	0.0550	131	5	5	0	5	5	1
11954.2508	0.1110	211	5	3	2	6	3	3
11954.6988	0.5400	211	6	0	6	7	0	7
11954.9147	0.2290	211	6	1	6	7	1	7
11956.4966	0.0220							
11958.0350	0.0130	310	2	2	1	3	3	0
11958.3581	0.0240	131	6	2	4	5	2	3
11960.1657	0.2060	211	5	1	4	6	1	5
11961.9297	0.3110	211	5	3	3	6	3	4
11963.5338	0.1540	211	5	4	2	6	4	3
11966.8031	0.0140							
11967.0741	0.0090							
11967.6750	0.4980	211	5	2	4	6	2	5
11967.9506	0.0140	131	5	3	2	4	3	1
11968.0761	0.0290	211	7	1	7	7	1	6
11968.1620	0.0480	211	5	5	1	6	5	2
11968.1620	0.0480	211	5	5	0	6	5	1
11968.6777	0.0330	310	5	2	4	6	1	5
11968.7411	0.0130							
11969.0961	0.0240	310	5	0	5	6	1	6
11970.6716	0.0180	310	5	1	5	6	0	6
11971.5702	0.0170	310	2	1	2	3	2	1
11973.7839	0.0080							
11973.8753	0.0510	211	2	0	2	3	2	1
11974.5498	0.0090	310	5	4	1	5	5	0
11975.8991	0.0130							
11976.9415	0.0070	310	7	3	5	7	4	4
11979.1773	0.6080	211	4	2	2	5	2	3
11979.7748	0.3410	211	5	0	5	6	0	6
11980.2401	0.7230	211	5	1	5	6	1	6
11981.1306	0.0090							
11981.3920	0.0100	211	7	1	6	7	3	5
11981.6755	0.0080							
11981.6972	0.0090							
11983.0374	0.0080	211	8	2	7	8	2	6
11984.6982	0.7120	211	4	1	3	5	1	4
11986.3649	0.0110							
11986.6404	0.4040	211	4	3	1	5	3	2
11987.2914	0.0140	310	6	3	4	6	4	3
11988.0256	0.0610	211	6	0	6	6	2	5
11990.2385	0.1640	211	4	3	2	5	3	3
11990.4411	0.0260	131	6	3	3	5	3	2
11991.1514	0.0110	310	6	2	5	6	3	4
11992.2265	0.0090	310	4	0	4	5	1	5
11992.5938	0.1640	211	4	4	0	5	4	1
11992.8068	0.0650	211	4	4	1	5	4	2
11993.3372	0.2940	211	4	2	3	5	2	4
11995.8419	0.0910	310	4	1	4	5	0	5
11996.1852	0.0080							
11996.5025	0.0370	211	6	1	5	6	3	4
11997.7226	0.0240	211	6	1	6	6	1	5
11998.7718	0.0070							
11999.6696	0.0120	310	5	3	2	5	4	1
12000.1092	0.0160	310	4	3	2	4	4	1
12000.4430	0.0320	310	4	2	3	5	1	4
12000.6592	0.0090							
12000.8109	0.0100							
12001.5085	0.0080							
12002.5274	0.0080							
12002.9146	0.0100							
12003.5324	0.8350	211	4	0	4	5	0	5
12003.7345	0.0200							
12003.7644	0.0240	211	4	1	3	4	3	2
12004.6449	0.4620	211	4	1	4	5	1	5
12006.6378	0.0190							
12008.2656	0.0070	211	9	3	7	9	3	6
12008.6972	0.0080	310	1	1	1	2	2	0
12009.2626	0.0130	310	5	2	4	5	3	3
12009.5330	0.0070							
12009.6528	0.3660	211	3	2	1	4	2	2
12010.1436	0.4440	211	3	1	2	4	1	3
12010.4539	0.0350	211	5	0	5	5	2	4
12012.2325	0.0070	131	7	3	4	6	3	3
12013.2128	0.0120	310	3	0	3	4	1	4
12015.2843	0.0400	211	7	2	6	7	2	5
12015.3725	0.0140	310	1	1	0	2	2	1
12015.4094	0.0070							
12016.9953	0.1570	211	3	3	0	4	3	1
12017.5182	0.0200	131	5	4	2	4	4	1
12017.7090	0.0080	131	5	4	1	4	4	0
12018.1742	0.4010	211	3	3	1	4	3	2
12018.9409	0.0110							
12019.0320	0.7310	211	3	2	2	4	2	3
12019.1134	0.0100	032	3	3	0	4	2	3
12019.5104	0.0380	310	4	2	3	4	3	2
12020.8821	0.0730	310	3	1	3	4	0	4
12025.2447	0.0070	310	7	2	5	7	3	4
12026.0471	0.5170	211	3	0	3	4	0	4
12026.6391	0.0120	310	3	2	2	3	3	1
12027.2256	0.1190	211	5	1	5	5	1	4
12028.1987	0.0150							
12028.2816	0.9100	211	3	1	3	4	1	4
12028.9587	0.1330	211	4	0	4	4	2	3
12032.5964	0.0230	310	3	2	1	3	3	0
12034.2271	0.0090	310	4	2	2	4	3	1
12034.7726	0.0090							
12035.1640	0.0080							
12035.4256	0.0180	310	5	2	3	5	3	2
12036.6591	0.8820	211	2	1	1	3	1	2
12037.5153	0.4350							
12037.5939	0.0130	310	4	3	2	5	2	3
12038.9120	0.0200	131	6	4	2	5	4	1
12039.9675	0.6680	211	2	2	0	3	2	1
12040.3763	0.0070	211	8	3	6	8	3	5
12040.6939	0.0100	131	6	4	3	6	2	4
12041.7730	0.0090							
12042.5257	0.0500	211	3	0	3	3	2	2
12044.6076	0.3090	211	2	2	1	3	2	2
12046.0359	0.7110	310	2	1	2	3	0	3
12047.1757	0.0160	310	5	1	4	5	2	3
12048.3391	0.7780	211	2	0	2	3	0	3
12050.7539	0.0120	310	1	0	1	2	1	2
12051.1996	0.0770	211	2	0	2	2	2	1
12051.3523	0.5560	211	2	1	2	3	1	3
12053.5208	0.0120							
12055.0059	0.0120	131	5	4	2	5	2	3
12055.0572	0.0780	211	4	1	4	4	1	3
12056.2094	0.0080							
12057.4097	0.0090							
12058.1206	0.0270							
12059.0438	0.0110	310	4	1	3	4	2	2

TABLE II—*Continued*

Sigma,cm-1	Depth,%	VIB	J'	Ka'	Kc'	J''	Ka''	Kc''
12060.6233	0.0140	131	7	4	4	6	4	3
12061.2507	0.0080	211	9	4	6	9	4	5
12062.4100	0.5260							
12063.7170	0.4310	211	1	1	0	2	1	1
12064.1551	0.0190	310	3	0	3	3	1	2
12064.2318	0.0100							
12064.4534	0.0350	310	3	1	2	3	2	1
12065.0684	0.0110	310	2	1	1	2	2	0
12067.0345	0.0530	211	7	3	5	7	3	4
12069.5154	0.5600	211	1	0	1	2	0	2
12071.0346	0.4910							
12072.9676	0.2060	211	5	2	4	5	2	3
12073.5504	0.0180	310	1	1	1	2	0	2
12073.9572	0.8420	211	1	1	1	2	1	2
12074.0702	0.0080							
12074.7445	0.0090							
12078.4876	0.0100							
12079.2274	0.3700	211	3	1	3	3	1	2
12080.1311	0.0080							
12080.1475	0.0080	211	8	4	5	8	4	4
12082.2235	0.4910							
12084.9895	0.0080	211	9	5	5	9	5	4
12086.8409	0.0080							
12087.6076	0.0530	211	6	3	4	6	3	3
12087.7143	0.0300	310	1	0	1	1	1	0
12090.1106	0.0090							
12093.0418	0.8320	211	0	0	0	1	0	1
12093.9541	0.0730	211	7	4	4	7	4	3
12094.8612	0.0100	211	8	5	4	8	5	3
12096.4192	0.0290	211	8	5	3	8	5	4
12098.0248	0.0090	131	6	5	1	5	5	0
12098.1338	0.2770	211	2	1	2	2	1	1
12100.2879	0.0090	211	4	2	2	5	0	5
12100.6063	0.0260	211	8	4	4	8	4	5
12101.5833	0.3580	211	5	3	3	5	3	2
12101.9062	0.0270	211	7	4	3	7	4	4
12102.6500	0.0650	211	7	5	3	7	5	2
12102.8757	0.0080	211	3	2	1	4	0	4
12103.0425	0.0200	211	7	5	2	7	5	3
12103.2339	0.0700	211	6	4	3	6	4	2
12104.3777	0.0080							
12105.6588	0.1900	211	6	4	2	6	4	3
12106.1495	0.0080							
12106.2441	0.0130							
12106.8528	0.7440	211	3	2	2	3	2	1
12108.3200	0.4430	310	6	0	6	7	1	7
12109.1140	0.0600	211	6	5	2	6	5	1
12109.1847	0.1630	211	6	5	1	6	5	2
12109.7741	0.4060	211	5	4	2	5	4	1
12110.1322	0.2990	211	4	3	2	4	3	1
12110.3002	0.1590	211	5	4	1	5	4	2
12110.9224	0.8870	211	1	1	1	1	1	0
12111.1335	0.0110							
12112.2645	0.1440	211	5	3	2	5	3	3
12112.5004	0.0520	211	3	0	3	2	2	0
12112.5004	0.0520	211	7	6	2	7	6	1
12113.0777	0.6630	211	4	3	1	4	3	2
12114.4261	0.0180	211	2	2	0	3	0	3
12114.5746	0.7060	211	2	2	1	2	2	0
12114.5746	0.7060	211	5	5	0	5	5	1
12114.6810	0.3290	211	4	4	1	4	4	0
12114.7435	0.6970	211	4	4	0	4	4	1
12115.0159	0.1610	211	6	3	3	6	3	4
12115.1587	0.9080	211	3	3	1	3	3	0
12115.6032	0.5370	211	3	3	0	3	3	1
12115.8233	0.0070							
12116.4906	0.0110	310	4	2	3	3	3	0
12116.7809	0.0210	211	4	0	4	3	2	1
12117.2909	0.9570	211	2	2	0	2	2	1
12117.4060	0.0100							
12118.0268	0.1310	211	6	6	1	6	6	0
12118.0268	0.1310	211	6	6	0	6	6	1
12118.3135	0.0110							
12119.2003	0.0120	112	4	4	1	5	5	0
12119.2003	0.0120	112	4	4	0	5	5	1
12119.3563	0.3690	211	3	2	1	3	2	2
12121.7570	0.5160	211	1	1	0	1	1	1
12122.2750	0.0220	211	7	3	4	7	3	5
12122.2750	0.0220	211	8	1	7	7	3	4
12123.1606	0.0070							
12125.0952	0.0250	310	1	1	0	1	0	1
12125.7156	0.4630	211	4	2	2	4	2	3
12127.1479	0.0140							
12127.2262	0.0120							
12127.4608	0.4000							
12129.3401	0.0080							
12129.9227	0.0100	310	2	1	1	2	0	2
12130.5533	0.6310	211	2	1	1	2	1	2
12131.2115	0.0090							
12131.4972	0.0140							
12132.0041	0.0090							
12133.5367	0.0340	211	8	3	5	8	3	6
12136.1571	0.0160	211	6	1	5	5	3	2
12136.5726	0.0910	211	5	2	3	5	2	4
12137.1034	0.0100	310	2	0	2	1	1	1
12137.9596	0.0080							
12138.9279	0.0240	310	3	1	2	3	0	3
12139.4430	0.4090	211	1	0	1	0	0	0
12141.7730	0.0160	310	3	1	2	2	2	1
12142.0251	0.0120	310	3	2	1	3	1	2
12142.3504	0.0140	112	4	3	2	5	4	1
12143.3790	0.1660	211	3	1	2	3	1	3
12143.4749	0.0540	310	1	1	1	0	0	0
12144.9879	0.0070							
12145.4445	0.5000							
12146.9619	0.0090							
12149.9170	0.5220							
12150.7173	0.0100	310	6	2	4	6	1	5
12151.0910	0.1110	211	6	2	4	6	2	5
12151.8238	0.6170							
12155.4546	0.0170							
12155.7340	0.0090	112	8	1	8	9	0	9
12156.1730	0.5110	211	2	1	2	1	1	1
12156.6419	0.0090							
12158.0498	0.0320	310	3	0	3	2	1	2
12158.1007	0.0130	112	4	2	3	5	3	2
12158.6176	0.5980	310	2	1	2	1	0	1
12159.2303	0.2600	211	4	1	3	4	1	4
12160.9207	0.8870	211	2	0	2	1	0	1
12161.0028	0.0110							
12161.2743	0.0080							
12161.8598	0.0170	310	5	2	3	4	3	2
12161.9586	0.0130	112	5	2	3	6	3	4
12165.3977	0.0070							
12167.0540	0.0140	112	7	1	6	8	2	7
12167.5187	0.8790	211	2	1	1	1	1	0
12167.7589	0.0210	211	7	2	5	7	2	6
12168.7497	0.0110	310	4	1	3	3	2	2
12169.3719	0.0080							
12170.3830	0.0280							
12170.9465	0.0090	112	3	3	1	4	4	0
12171.0325	0.0210	112	3	3	0	4	4	1
12172.1884	0.0290	310	3	1	3	2	0	2
12173.0405	0.0150							
12173.1215	0.9600	211	3	1	3	2	1	2
12173.2317	0.0110							
12174.5243	0.0080	310	7	3	4	6	4	3
12175.8724	0.0090	310	4	0	4	3	1	3
12176.1292	0.0550	211	5	1	4	5	1	5
12176.9974	0.0160							
12177.3536	0.6820	211	3	0	3	2	0	2
12179.4368	0.0310	211	2	2	1	2	0	2
12179.8826	0.0190							
12180.1593	0.0100	112	4	2	2	5	3	3
12181.3154	0.1600	211	3	2	2	3	0	3
12183.5473	0.0130	310	4	1	4	3	0	3
12183.7409	0.0120							
12183.9477	0.0370	112	7	0	7	8	1	8
12184.1765	0.7600	211	3	2	2	2	2	1
12184.2586	0.0120	032	3	3	0	2	2	1
12184.4142	0.0160	310	6	1	5	6	0	6
12184.4142	0.0160	112	7	1	7	8	0	8
12184.4964	0.0210	211	8	2	6	8	2	7
12186.2702	0.0610	211	4	2	3	4	0	4
12188.2926	0.6510	211	4	1	4	3	1	3
12188.9990	0.0070							
12189.3290	0.3770	211	3	2	1	2	2	0
12189.4010	0.0170							
12190.1582	0.5960	211	3	1	2	2	1	1
12190.6103	0.0090	310	5	0	5	4	1	4
12191.2427	0.9750	211	4	0	4	3	0	3
12193.1005	0.0110	112	3	2	2	4	3	1
12193.6157	0.0090	112	3	1	3	4	2	2
12193.7184	0.0370	310	5	1	4	4	2	3
12194.0790	0.1340	211	5	2	4	5	0	5
12195.1910	0.5810							
12196.5405	0.0350	211	6	1	5	6	1	6
12197.0834	0.0070							

TABLE II—*Continued*

Sigma,cm-1	Depth,%	VIB	J'	Ka'	Kc'	J''	Ka''	Kc''
12198.3188	0.0660	310	2	2	1	1	1	0
12198.4443	0.0090							
12199.5828	0.0090							
12200.9983	0.0350	112	3	2	1	4	3	2
12201.5409	0.0200	131	5	4	2	4	2	3
12201.6774	0.0120							
12201.7579	0.9420	211	5	1	5	4	1	4
12202.0286	0.4840							
12202.7491	0.4500	211	4	2	3	3	2	2
12203.1455	0.0210	112	6	2	5	7	1	6
12203.3869	0.6040	211	5	0	5	4	0	4
12203.6143	0.0090							
12204.3461	0.0100	310	7	2	6	7	1	7
12204.6132	0.0090	310	6	1	6	5	0	5
12204.7434	0.0260	211	6	2	5	6	0	6
12204.8894	0.0400	211	7	3	5	7	1	6
12204.8894	0.0400	310	2	2	0	1	1	1
12205.0391	0.0190	211	6	3	4	6	1	5
12205.1319	0.0310	131	7	3	5	6	1	6
12207.6329	0.0220							
12207.7518	0.6260							
12208.1905	0.0370	112	5	1	4	6	2	5
12208.7398	0.2110	211	4	3	2	3	3	1
12208.9515	0.0590	211	5	3	3	5	1	4
12210.0624	0.5210	211	4	3	1	3	3	0
12210.1758	0.9250	211	4	1	3	3	1	2
12210.8977	0.0580	112	6	1	6	7	0	7
12211.9595	0.0450	211	7	2	6	7	0	7
12213.2748	0.0070							
12213.3021	0.0100	211	9	3	7	9	1	8
12213.4535	0.0120							
12213.5365	0.8360	211	4	2	2	3	2	1
12213.6854	0.4970	211	6	1	6	5	1	5
12213.6854	0.4970	310	7	0	7	6	1	6
12213.9508	0.0410	310	3	2	2	2	1	1
12214.4298	0.8770	211	6	0	6	5	0	5
12215.0924	0.0080	310	6	1	5	5	2	4
12215.2704	0.0140							
12216.0323	0.0140	211	4	3	2	4	1	3
12216.1070	0.0100							
12217.8926	0.0100							
12218.1184	0.0150							
12218.7558	0.0120							
12219.4211	0.0210	310	7	2	5	6	3	4
12219.5058	0.7930	211	5	2	4	4	2	3
12220.8298	0.0200	211	8	1	7	8	1	8
12224.2818	0.0140							
12224.4241	0.7390	211	7	1	7	6	1	6
12224.5858	0.0230	211	3	3	1	3	1	2
12225.5104	0.0170	112	4	1	3	5	2	4
12225.9209	0.1900	310	4	2	3	3	1	2
12226.1016	0.6590							
12226.4197	0.0190							
12226.5428	0.4160	211	5	1	4	4	1	3
12227.0123	0.0640	211	2	2	0	1	0	1
12227.7639	0.0760	131	6	4	3	5	2	4
12228.0206	0.5530	211	5	3	3	4	3	2
12229.7483	0.0130							
12230.8613	0.0090							
12231.4989	0.0100							
12231.8583	0.0130	211	9	2	8	9	0	9
12231.9231	0.2360	211	5	4	2	4	4	1
12232.1613	0.2910	211	5	3	2	4	3	1
12232.1613	0.2910	211	5	4	1	4	4	0
12232.5788	0.2290	211	8	1	8	7	1	7
12233.3175	0.0110	112	5	2	4	6	1	5
12233.8074	0.5440	211	8	0	8	7	0	7
12234.0676	0.0130							
12234.7500	0.0730	112	5	0	5	6	1	6
12235.0565	0.1300	310	5	2	4	4	1	3
12235.4198	0.2640	211	6	2	5	5	2	4
12235.9193	0.0440	310	3	2	1	2	1	2
12236.2815	0.3920	211	5	2	3	4	2	2
12236.5607	0.5890							
12238.0468	0.0230	112	2	1	2	3	2	1
12238.1841	0.3900	310	6	2	5	5	1	4
12239.1961	0.0110	211	7	4	4	7	2	5
12239.8084	0.0070							
12240.2277	0.1330	211	9	0	9	8	0	8
12240.8975	0.3440	211	9	1	9	8	1	8
12241.8454	0.0130							
12242.5933	0.0440	112	3	1	2	4	2	3
12243.5254	0.5900	211	6	1	5	5	1	4
12244.2261	0.0080	112	6	1	6	6	2	5
12244.7189	0.5460							
12245.6209	0.1840	211	6	3	4	5	3	3
12246.9619	0.0670	211	10	1	10	9	1	9
12247.0307	0.1890	211	10	0	10	9	0	9
12247.1534	0.0470	310	7	2	6	6	1	5
12248.0200	0.4350							
12249.3900	0.4840							
12250.3484	0.0100							
12250.8770	0.0880	211	6	4	3	5	4	2
12251.8991	0.2400	211	6	4	2	5	4	1
12252.3031	0.1130	211	11	0	11	10	0	10
12252.3031	0.1130	211	11	1	11	10	1	10
12252.9682	0.1920	211	7	1	6	6	1	5
12253.7380	0.0090							
12254.1863	0.0490	211	6	4	3	6	2	4
12254.6702	0.4570	211	6	3	3	5	3	2
12255.5755	0.0770	211	6	5	1	5	5	0
12256.0596	0.0550	310	3	3	0	2	2	1
12256.3155	0.0460	211	12	0	12	11	0	11
12256.3155	0.0469	211	12	1	12	11	1	11
12256.3831	0.6230	211	6	2	4	5	2	3
12256.6709	0.1260	211	8	2	7	7	2	6
12258.2980	0.0350	112	4	0	4	5	1	5
12259.0742	0.0190							
12260.1349	0.3240	211	8	1	7	7	1	6
12260.8126	0.0190	112	2	1	1	3	2	2
12261.2013	0.3530	131	7	4	4	6	2	5
12261.2013	0.3530	211	7	3	5	6	3	4
12261.7649	0.0970	112	4	1	4	5	0	5
12264.5600	0.0100	112	5	3	2	5	4	1
12265.4705	0.0330	112	4	2	3	5	1	4
12266.1991	0.1800	211	9	2	8	8	2	7
12268.4924	0.0650	211	9	1	8	8	1	7
12268.6214	0.1710	211	7	4	4	6	4	3
12271.3252	0.0550							
12271.6123	0.0610	211	7	4	3	6	4	2
12271.8384	0.0260							
12271.9498	0.0710	310	4	3	2	3	2	1
12272.6879	0.0070							
12273.1193	0.1540	211	7	2	5	6	2	4
12273.3644	0.0100	310	4	2	2	3	1	3
12273.6923	0.0260							
12273.7754	0.0670	211	7	5	3	6	5	2
12273.9215	0.0260	211	7	5	2	6	5	1
12274.0169	0.0180	112	1	1	1	2	2	0
12274.9397	0.0680	211	8	3	6	7	3	5
12275.4115	0.0160							
12275.6337	0.0070							
12276.4286	0.1190	211	7	3	4	6	3	3
12278.8779	0.0320							
12279.1223	0.1030	112	3	0	3	4	1	4
12279.4123	0.0180	310	4	3	1	3	2	2
12280.3615	0.0120	211	11	1	10	10	1	9
12280.9083	0.0540	112	1	1	0	2	2	1
12281.7338	0.0120	112	5	0	5	5	1	4
12282.3552	0.0210							
12284.3074	0.0140							
12284.5368	0.0130	112	4	2	3	4	3	2
12284.6865	0.0340	211	8	4	5	7	4	4
12284.8412	0.0250	310	5	3	3	4	2	2
12285.7286	0.0150							
12285.9582	0.2130	211	8	2	6	7	2	5
12286.3518	0.0940	211	9	3	7	8	3	6
12287.1908	0.0150	112	4	1	4	4	2	3
12287.9993	0.1080	211	4	2	2	3	0	3
12288.2922	0.0080							
12289.7522	0.0090							
12291.5455	0.0970	211	8	4	4	7	4	3
12293.1636	0.0640	310	6	3	4	5	2	3
12293.4079	0.0070	013	8	1	7	9	1	8
12294.1731	0.0070							
12295.0577	0.0210							
12295.7066	0.1660	211	8	3	5	7	3	4
12297.6027	0.0180	310	7	3	5	6	2	4
12297.9656	0.0150							
12298.1427	0.0360	112	2	0	2	3	1	3
12298.9937	0.0110	112	3	2	2	4	1	3
12299.8203	0.0480	211	9	4	6	8	4	5
12301.2038	0.0520	310	8	3	6	7	2	5
12301.6095	0.0140	112	5	2	3	5	3	2
12301.9793	0.0110	112	4	3	2	5	2	3
12302.2978	0.0220							
12302.9077	0.0120	211	3	3	0	2	1	1
12303.3252	0.0090	112	3	1	3	3	2	2

TABLE II—*Continued*

Sigma,cm-1	Depth,%	VIB	J'	Ka'	Kc'	J''	Ka''	Kc''
12304.8737	0.0170							
12305.8476	0.0410	310	5	3	2	4	2	3
12306.2459	0.0090	211	6	4	2	6	2	5
12306.9904	0.0430	211	10	2	8	9	2	7
12307.2389	0.0220	211	9	5	5	8	5	4
12308.1459	0.0150	013	8	0	8	9	0	9
12308.2744	0.0440	310	4	4	1	3	3	0
12308.5297	0.0170	310	4	4	0	3	3	1
12308.7112	0.0100	112	4	0	4	4	1	3
12309.7349	0.0090							
12311.0957	0.0250							
12311.4228	0.0190							
12311.8975	0.0080							
12312.0226	0.0110							
12312.5085	0.0850	112	2	1	2	3	0	3
12313.4792	0.0310	112	5	1	4	5	2	3
12314.0219	0.0090							
12315.0578	0.0080							
12315.3696	0.0210	112	2	1	2	2	2	1
12316.5322	0.0800	112	1	0	1	2	1	2
12317.3212	0.0130	310	5	2	3	4	1	4
12318.4764	0.0200	211	3	3	1	2	1	2
12318.4764	0.0200							
12319.0508	0.0090	013	7	1	6	8	1	7
12319.4858	0.0600	211	4	3	1	3	1	2
12319.5603	0.0120							
12320.7367	0.0200							
12321.4010	0.0100							
12321.6615	0.0150							
12322.5443	0.0130	013	7	2	6	8	2	7
12322.6870	0.0090							
12324.8095	0.0140	013	6	3	3	7	3	4
12325.0250	0.0090							
12325.2292	0.0170	112	4	1	3	4	2	2
12325.8999	0.0090							
12325.9767	0.0090	131	6	5	1	5	3	2
12326.9161	0.0100							
12327.2661	0.0150	310	5	4	2	4	3	1
12328.8991	0.0230	013	6	2	4	7	2	5
12328.9425	0.0390	310	5	4	1	4	3	2
12329.0109	0.0080	013	6	4	2	7	4	3
12329.5048	0.0250	211	5	2	3	4	0	4
12329.7138	0.0210							
12330.0682	0.0510	112	3	0	3	3	1	2
12330.4144	0.0490	112	3	1	2	3	2	1
12330.7909	0.0130	112	2	1	1	2	2	0
12332.4621	0.0170	112	2	2	1	3	1	2
12332.5775	0.0150							
12333.2755	0.0080							
12334.6784	0.0330	013	7	1	7	8	1	8
12334.8648	0.0070							
12334.9632	0.0080							
12335.9580	0.0230	112	0	0	0	1	1	1
12338.0579	0.0260	211	5	3	2	4	1	3
12338.8125	0.0100							
12338.8768	0.0180	112	1	1	1	2	0	2
12340.1916	0.0130							
12343.1607	0.0090	310	6	4	3	5	3	2
12343.3750	0.0300	310	6	4	3	5	3	2
12343.5457	0.0290	013	6	1	5	7	1	6
12344.9226	0.0280	112	2	0	2	2	1	1
12346.1631	0.0100							
12346.2864	0.0100	013	6	2	5	7	2	6
12348.2446	0.0100							
12349.2670	0.0130	211	4	3	2	3	1	3
12349.6525	0.0110							
12350.7778	0.0130							
12353.4968	0.0700	112	1	0	1	1	1	0
12354.4975	0.0110	310	7	4	4	6	3	3
12354.5669	0.0110	013	5	3	2	6	3	3
12355.3827	0.0160	013	5	2	3	6	2	4
12357.8530	0.0100	013	5	4	2	6	4	3
12358.0926	0.0130	310	5	5	1	4	4	0
12358.1481	0.0340	310	5	5	0	4	4	1
12360.0140	0.0190	013	6	1	6	7	1	7
12360.2333	0.0500	013	6	0	6	7	0	7
12361.1830	0.0250	013	5	3	3	6	3	4
12361.4979	0.0100							
12361.5980	0.0090							
12362.0376	0.0600	211	6	3	3	5	1	4
12366.1051	0.0070	310	7	5	2	7	2	5
12367.0875	0.0220	013	5	1	4	6	1	5
12367.0875	0.0220	310	6	0	6	5	1	5
12370.9268	0.0460	013	5	2	4	6	2	5
12372.4230	0.0150							
12375.1063	0.0090	310	7	3	4	6	2	5
12375.3761	0.0100							
12376.7866	0.0260	310	6	5	2	5	4	1
12377.0123	0.0100	013	2	0	2	3	2	1
12377.2609	0.0110	310	6	5	1	5	4	2
12377.4958	0.0300	211	6	2	4	5	0	5
12380.4539	0.0150	013	4	4	0	5	4	1
12380.6571	0.0080	013	4	4	1	5	4	2
12382.8521	0.0660	013	4	2	2	5	2	3
12383.4836	0.0260	211	5	3	3	4	1	4
12383.9165	0.0350	013	4	3	1	5	3	2
12384.6787	0.0290	013	5	0	5	6	0	6
12385.3157	0.0730	013	5	1	5	6	1	6
12386.5869	0.0160	211	4	4	0	3	2	1
12387.1559	0.0130	013	4	3	2	5	3	3
12387.6591	0.0110							
12390.4936	0.0870	013	4	1	3	5	1	4
12390.6292	0.0900	112	1	1	0	1	0	1
12392.5901	0.0080	211	4	4	1	3	2	2
12393.8568	0.0120	211	7	3	4	6	1	5
12395.4150	0.0340	013	4	2	3	5	2	4
12395.5337	0.0140	310	7	5	2	6	4	3
12395.6443	0.0410	112	2	1	1	2	0	2
12399.8585	0.0080	013	6	1	5	6	3	4
12402.9564	0.0120	112	2	0	2	1	1	1
12404.8771	0.0820	112	3	1	2	3	0	3
12405.9519	0.0280	112	4	2	2	4	1	3
12406.2214	0.0110							
12407.4067	0.0850	112	3	2	1	3	1	2
12407.7417	0.0080	112	3	1	2	2	2	1
12407.9425	0.1110	013	4	0	4	5	0	5
12408.7975	0.0210	112	1	1	1	0	0	0
12408.9750	0.0600	112	5	2	3	5	1	4
12409.5732	0.0080	013	4	1	3	4	3	2
12410.6709	0.0150	112	7	3	4	7	2	5
12411.1951	0.0310	013	3	2	1	4	2	2
12411.4072	0.0090							
12411.5328	0.0230	211	6	4	2	5	2	3
12411.9573	0.0310	013	3	3	0	4	3	1
12411.9573	0.0310	112	2	2	0	2	1	1
12412.3122	0.0130							
12413.0650	0.0350	013	3	3	1	4	3	2
12414.7419	0.0410	013	3	1	2	4	1	3
12415.2080	0.0160							
12415.9450	0.0220	211	5	4	2	4	2	3
12416.0545	0.0110	112	6	3	3	6	2	4
12417.9656	0.0130	112	6	2	4	6	1	5
12418.4569	0.0220	112	4	1	3	4	0	4
12419.8269	0.0830	013	3	2	2	4	2	3
12421.0037	0.0100	211	6	3	4	5	1	5
12422.5641	0.0080	211	7	4	3	6	2	4
12423.9618	0.0480	112	3	0	3	2	1	2
12424.1822	0.0380	112	5	3	2	5	2	3
12425.0902	0.0670	112	2	1	2	1	0	1
12426.3532	0.0480	112	2	2	1	2	1	2
12429.9640	0.0500	013	3	0	3	4	0	4
12430.5560	0.0160							
12431.9019	0.1370	013	3	1	3	4	1	4
12432.2318	0.0220	112	3	2	2	3	1	3
12433.3689	0.0180	013	4	0	4	4	2	3
12433.5617	0.0160	211	8	3	5	7	1	6
12434.0489	0.0160	112	4	3	1	4	2	2
12434.5924	0.0380	112	5	1	4	5	0	5
12434.9299	0.0070	112	4	1	3	3	2	2
12436.7884	0.0150	211	8	4	4	7	2	5
12438.1534	0.0240	112	3	1	3	2	0	2
12439.0141	0.0100							
12439.8160	0.0770	013	2	2	0	3	2	1
12440.0035	0.0480	112	4	2	3	4	1	4
12440.1105	0.1340	013	2	1	1	3	1	2
12441.2615	0.0090	211	6	4	3	5	2	4
12441.9497	0.0170	112	4	0	4	3	1	3
12442.8769	0.0410	112	3	3	0	3	2	1
12444.0918	0.0090							
12444.2731	0.0270	013	2	2	1	3	2	2
12446.4441	0.0080	013	3	0	3	3	2	2
12448.5212	0.0380	112	4	3	2	4	2	3
12448.8531	0.0100	112	3	3	1	3	2	2
12449.2840	0.0120	112	5	2	4	5	1	5
12449.4758	0.0530	112	4	1	4	3	0	3
12449.9547	0.0110	112	5	3	3	5	2	4
12451.4787	0.1630	013	2	0	2	3	0	3
12452.0808	0.0150	112	6	3	4	6	2	5

TABLE II—*Continued*

Sigma,cm-1	Depth,%	VIB	J'	Ka'	Kc'	J''	Ka''	Kc''
12454.3237	0.0570	013	2	1	2	3	1	3
12454.6188	0.0110							
12454.7548	0.0080							
12456.2677	0.0400	112	5	0	5	4	1	4
12459.4921	0.0230	112	6	2	5	6	1	6
12460.0184	0.0150	112	5	1	4	4	2	3
12460.2372	0.0140	112	5	1	5	4	0	4
12461.2379	0.0110	211	7	3	5	6	1	6
12463.3204	0.0720	112	2	2	1	1	1	0
12464.5296	0.0250	112	5	4	1	5	3	2
12465.1873	0.0150	112	7	1	6	7	0	7
12465.9009	0.0160	112	8	3	6	8	2	7
12466.2954	0.0400	013	1	1	0	2	1	1
12468.8434	0.0100	112	6	0	6	5	1	5
12468.9415	0.0090	211	5	5	1	4	3	2
12469.1980	0.0130	211	7	4	4	6	2	5
12469.5939	0.0110	112	5	4	2	5	3	3
12470.0032	0.0250	112	2	2	0	1	1	1
12470.6284	0.0250	112	6	1	6	5	0	5
12472.1862	0.0090	112	4	4	0	4	3	1
12473.3015	0.0530	013	1	0	1	2	0	2
12473.5935	0.0270	112	4	4	1	4	3	2
12475.0569	0.0080							
12476.2220	0.0170	013	5	2	4	5	2	3
12476.9520	0.0130							
12477.4537	0.0070							
12479.0107	0.0210	112	3	2	2	2	1	1
12479.2579	0.0110							
12479.5957	0.0160	112	7	0	7	6	1	6
12480.4865	0.0080	112	7	1	7	6	0	6
12480.7431	0.0090	013	6	6	1	6	6	0
12480.7431	0.0090	013	6	6	0	6	6	1
12482.7952	0.0090							
12482.8485	0.0360	013	3	1	3	3	1	2
12483.5309	0.0090	211	6	5	1	5	3	2
12484.9746	0.0160							
12485.1034	0.0120							
12487.9455	0.0100							
12488.0619	0.0110							
12488.2187	0.0180	013	6	5	1	6	5	2
12488.2187	0.0180	112	8	1	8	7	0	7
12489.4346	0.0100	112	8	0	8	7	1	7
12490.9493	0.0400	112	4	2	3	3	1	2
12492.2706	0.0330	013	5	5	1	5	5	0
12492.2706	0.0330	013	5	5	0	5	5	1
12493.8675	0.0310	112	9	1	9	8	0	8
12493.8675	0.0310	112	5	5	0	5	4	1
12494.2856	0.0130	112	5	5	1	5	4	2
12495.1192	0.0180	013	4	2	3	4	2	2
12496.3693	0.1020	013	0	0	0	1	0	1
12498.5143	0.0090	112	7	1	6	6	2	5
12499.6986	0.0120	112	5	2	4	4	1	3
12500.8390	0.0270	013	5	3	3	5	3	2
12501.1013	0.0240	013	2	1	2	2	1	1
12501.3012	0.0350	112	3	2	1	2	1	2
12502.0197	0.0100							
12502.5236	0.0250	013	4	4	1	4	4	0
12502.6008	0.0720	013	4	4	0	4	4	1
12504.0928	0.0110	013	5	4	2	5	4	1
12506.4762	0.0190	112	6	2	5	5	1	4
12507.0487	0.0220	013	4	3	2	4	3	1
12507.6486	0.0850	013	3	2	2	3	2	1
12508.4664	0.0110	211	7	5	3	6	3	4
12510.0492	0.1380	013	3	3	1	3	3	0
12510.3558	0.0620	013	4	3	1	4	3	2
12510.5554	0.0480	013	3	3	0	3	3	1
12510.8095	0.0110							
12512.5748	0.0100	013	5	3	2	5	3	3
12513.3487	0.1360	013	1	1	1	1	1	0
12514.2440	0.0640	013	2	2	1	2	2	0
12517.1401	0.1730	013	2	2	0	2	2	1
12518.8341	0.0260	112	3	3	1	2	2	0
12518.9705	0.0090	013	6	3	3	6	3	4
12520.1980	0.0720	112	3	3	0	2	2	1
12520.8979	0.0310	013	3	2	1	3	2	2
12521.6093	0.0080							
12524.3353	0.0480	013	1	1	0	1	1	1
12528.4401	0.0070							
12529.3898	0.0330	013	4	2	2	4	2	3
12531.0492	0.0070							
12534.0045	0.0620	013	2	1	1	2	1	2
12536.3397	0.0470	112	4	3	2	3	2	1
12537.0874	0.0160							
12540.2296	0.0080							
12543.2289	0.0400	013	1	0	1	0	0	0
12543.7498	0.0150	112	4	3	1	3	2	2
12547.9728	0.0130	013	3	1	2	3	1	3
12549.6534	0.0100	112	5	3	3	4	2	2
12557.3758	0.0110	112	6	3	4	5	2	3
12559.1396	0.0500	013	2	1	2	1	1	1
12564.0602	0.1830	013	2	0	2	1	0	1
12565.0280	0.0200	013	4	1	3	4	1	4
12565.6424	0.0080	211	7	6	2	6	4	3
12567.3764	0.0070	112	8	3	6	7	2	5
12570.5746	0.0480	112	4	4	1	3	3	0
12570.7205	0.0190	112	5	3	2	4	2	3
12570.7846	0.0170	112	4	4	0	3	3	1
12570.9698	0.1290	013	2	1	1	1	1	0
12576.7418	0.1910	013	3	1	3	2	1	2
12581.2699	0.0680	013	3	0	3	2	0	2
12582.1071	0.0110	013	3	2	2	3	0	3
12583.6990	0.0120	112	3	3	1	2	0	2
12584.9717	0.0870	013	3	2	2	2	2	1
12590.8697	0.0350	013	3	2	1	2	2	0
12590.9673	0.0220	112	5	4	1	4	3	2
12592.5900	0.0710	013	4	1	4	3	1	3
12592.6441	0.0090							
12594.7564	0.0610	013	3	1	2	2	1	1
12595.6524	0.1950	013	4	0	4	3	0	3
12597.3234	0.0080	013	5	2	4	5	0	5
12604.8210	0.0430	013	4	2	3	3	2	2
12605.5431	0.0100	112	6	4	3	5	3	2
12605.6590	0.0220	013	4	3	2	3	3	1
12606.8334	0.1750	013	5	1	5	4	1	4
12607.3403	0.0560	013	4	3	1	3	3	0
12608.2911	0.0640	013	5	0	5	4	0	4
12609.6283	0.0080							
12610.7995	0.0100	112	4	3	2	3	0	3
12615.9711	0.1570	013	4	1	3	3	1	2
12617.2101	0.1130	013	4	2	2	3	2	1
12618.7855	0.0430	013	6	1	6	5	1	5
12619.6958	0.0070							
12619.9638	0.1330	013	6	0	6	5	0	5
12622.7572	0.1080	013	5	2	4	4	2	3
12626.2455	0.0410	013	5	4	2	4	4	1
12626.4283	0.0140	013	5	4	1	4	4	0
12627.2742	0.0620	013	5	3	3	4	3	2
12630.3286	0.0900	013	7	1	7	6	1	6
12630.7612	0.0340	013	7	0	7	6	0	6
12632.4670	0.0220	013	5	3	2	4	3	1
12633.4621	0.0420	211	8	4	4	7	0	7
12633.4621	0.0420	013	5	1	4	4	1	3
12633.9315	0.0070	112	6	2	4	5	1	5
12638.7168	0.0260	013	6	2	5	5	2	4
12640.4041	0.0200	013	8	1	8	7	1	7
12640.6283	0.0570	013	8	0	8	7	0	7
12642.1615	0.0340	013	5	2	3	4	2	2
12646.8802	0.0820	013	6	1	5	5	1	4
12647.4776	0.0180	013	6	3	4	5	3	3
12649.1257	0.0110	013	6	4	3	5	4	2
12649.2829	0.0340	013	9	1	9	8	1	8
12649.3710	0.0160	013	9	0	9	8	0	8
12649.9223	0.0310	013	6	4	2	5	4	1
12654.0081	0.0510	013	7	2	6	6	2	5
12657.1004	0.0170							
12657.3664	0.0190	013	7	1	6	6	1	5
12658.6286	0.0420	013	6	3	3	5	3	2
12662.2110	0.0100							
12664.1912	0.0650	013	6	2	4	5	2	3
12665.0836	0.0220	013	8	2	7	7	2	6
12666.4767	0.0270	013	8	1	7	7	1	6
12667.0256	0.0160	013	7	3	5	6	3	4
12668.8891	0.0170							
12670.6291	0.0190	013	7	4	4	6	4	3
12672.8665	0.0160	013	9	2	8	8	2	7
12673.1721	0.0090	013	7	4	3	6	4	2
12681.9506	0.0080							
12682.2180	0.0140	013	7	2	5	6	2	4
12684.1959	0.0100	013	7	3	4	6	3	3
12689.3194	0.0110							
12691.6703	0.0110	013	4	2	2	3	0	3
12693.1416	0.0130							
12694.4157	0.0140							
12695.5496	0.0200	013	8	2	6	7	2	5
12696.9141	0.0100							
12699.8582	0.0100							
12702.1805	0.0090							
12707.0617	0.0130							

TABLE III

Experimental Levels of the Vibrational States (211), (013), (310), (131), (112), and (230) of $H_2{}^{18}O$

J	Ka	Kc	State (211) Energy, cm-1	Delta, 10-3cm-1	State (013) Energy, cm-1	Delta, 10-3cm-1
0	0	0	12116.7966	0.10	12520.1241	3.65
1	0	1	12139.4429	0.14	12543.2289	0.04
1	1	1	12152.9457	0.05	12555.3721	0.77
1	1	0	12158.5055	0.09	12561.0839	0.04
2	0	2	12184.6752	0.60	12587.8151	0.09
2	1	2	12192.9213	0.92	12595.8898	1.32
2	1	1	12209.5418	0.15	12612.9931	0.09
2	2	1	12249.3636	0.48	12649.0279	0.78
2	2	0	12250.7667	0.33	12650.6154	0.53
3	0	3	12247.2807	0.66	12651.1975	0.31
3	1	3	12252.1100	0.23	12655.7305	0.47
3	1	2	12284.9466	0.06	12689.5448	0.03
3	2	2	12317.6519	0.27	12718.4472	0.44
3	2	1	12324.1119	0.18	12725.6534	0.47
3	3	1	12397.4658	0.22	12792.3564	0.07
3	3	0	12397.6972	0.80	12792.6502	1.14
4	0	4	12327.5789	0.52	12731.9888	0.22
4	1	4	12329.8602	0.06	12734.1577	12.72
4	1	3	12383.0583	0.32	12788.8539	0.18
4	2	3	12407.5045	0.36	12809.5791	2.61
4	2	2	12424.3352	0.44	12828.0088	1.24
4	3	2	12490.8345	0.18	12887.7521	1.23
4	3	1	12492.3689	0.50	12889.6474	0.22
4	4	1	12597.3524	1.47	12985.1989	2.38
4	4	0	12597.3866	0.65	12985.2457	1.07
5	0	5	12424.6210	0.39	12829.5248	0.13
5	1	5	12425.5860	0.04	12830.6616	0.02
5	1	4	12501.3452	0.65	12908.2664	1.33
5	2	4	12518.1255	0.07	12921.3781	1.41
5	2	3	12550.7405	0.20	12956.6202	0.10
5	3	3	12607.3118	0.18	13006.5660	0.88
5	3	2	12612.8605	0.28	13013.1720	3.12
5	4	2	12714.5669	0.12	13108.8858	0.11
5	4	1	12714.8444	0.29	13109.1012	1.93
5	5	1	12848.2385	0.94	13225.9536	1.67
5	5	0	12848.2768	0.94	13225.9499	1.67
6	0	6	12538.4763	0.14	12944.0106	0.28
6	1	6	12538.9008	0.06	12944.0005	0.34
6	1	5	12641.8855	0.57	13045.2405	0.30
6	2	5	12649.5879	0.39	13052.8842	0.26
6	2	4	12701.5415	0.26	13109.3504	1.22
6	3	4	12746.2170	0.19	13148.0734	2.41
6	3	3	12760.3982	0.14	13164.3576	0.84
6	4	3	12855.4218	0.82	13253.6699	6.06
6	4	2	12856.6916	0.45	13254.7130	2.19
6	5	2	12989.2288	0.81		
6	5	1	12989.2598	1.05	13368.2952	4.15
6	6	1	13151.2198	1.89	13513.9380	5.16
6	6	0	13151.2224	1.10	13513.9376	5.16
7	0	7	12669.3218	0.33	13075.6072	1.53
7	1	7	12669.7701	0.21	13075.6756	1.15
7	1	6	12794.1485	0.04	13198.5460	0.61
7	2	6	12795.7365	0.68	13204.4583	0.26
7	2	5	12874.3569	0.37	13283.4554	4.81
7	3	5	12906.5834	0.48	13312.4078	3.40
7	3	4	12935.0374	0.69	13342.8054	5.03
7	4	4	13019.6542	0.14	13421.6620	2.71
7	4	3	13023.8006	1.26	13425.3595	5.24
7	5	3	13153.8534	1.12		
7	5	2	13154.0338	1.80		
7	6	2	13316.6694	5.91		
7	6	1	13316.6707	0.96		
8	0	8	12817.5851	0.04	13224.4047	1.26
8	1	8	12816.5639	1.10	13224.3903	2.80
8	1	7	12961.8286	0.45	13368.1706	0.41
8	2	7	12963.2687	0.22	13371.6812	1.76
8	2	6	13066.4103	0.30	13476.0022	2.80
8	3	6	13087.7020	0.88		
8	3	5	13135.2554	0.64		
8	4	5	13206.5846	2.27		
8	4	4	13217.2429	1.59		
8	5	4	13342.0682	9.44		
9	0	9	12981.1400	0.20	13390.2831	1.90
9	1	9	12981.8960	0.10	13390.2813	1.71
9	1	8	13147.9879	0.88		
9	2	8	13148.1133	1.87	13554.7403	4.43
9	2	7	13282.5197	2.70		
9	3	7	13288.0560	1.34		
9	4	6	13416.4545	2.11		
9	5	5	13553.6082	2.11		
10	0	10	13163.2882	0.02		
10	1	10	13163.2552	0.72		
11	0	11	13362.0946	4.74		
11	1	11	13362.1035	1.37		
11	1	10	13568.0949	4.59		
12	0	12	13577.7737	4.29		
12	1	12	13577.7775	1.71		

Note. JK_aK_c is the rotational assignment of the level, and Delta corresponds to one standard deviation.

levels (131) [643] and (211) [625] separated by 3 cm^{-1} have mixing coefficients of 20 and 78%.

3. There is a strong linestrength redistribution among the resonating lines. More precisely, the lines belonging to the weakest band borrow part of their intensities from a stronger band through the mixing of the wavefunctions. For example, lines involving the levels (310) [836] and (112) [818] could not be observed in the spectrum in the absence of a resonance with the [826] level of the (211) state.

4. The level (211) [818], because of a complicated resonance coupling with the levels of the (131), (230), (310) states is shifted down by about 1 cm^{-1} from its unperturbed position and its position is inverted as compared to that of the level (211) [808].

TABLE III—*Continued*

J	Ka	Kc	State (310) Energy cm-1	Delta, 10-3cm-1	State (131) Energy cm-1	Delta, 10-3cm-1	J	Ka	Kc	State (112) Energy, cm-1	Sigma, 10-3cm-1	State (230) Energy, cm-1	Sigma, 10-3cm-1
0	0	0			11774.7084	1.63	0	0	0	12372.7066	2.81		
1	0	1	12129.7400	2.35	11797.9144	0.69	1	0	1	12395.5204	0.25	11757.5398	0.80
1	1	1	12143.4763	1.41	11820.0627	0.00	1	1	1	12408.8005	2.73		
1	1	0	12148.8492	0.88	11826.2578	0.94	1	1	0	12414.3841	0.02	11787.2896	6.98
2	0	2	12173.8520	4.34	11843.1441	0.29	2	0	2	12439.7107	0.29	11802.4795	4.01
2	1	2	12182.3724	0.01	11860.2638	0.04	2	1	2	12448.8453	0.26	11821.0746	0.04
2	1	1	12199.8508	0.74	11878.7946	0.83	2	1	1	12465.5713	2.40		
2	2	1	12240.3422	0.08	11943.4278	0.38	2	2	1	12505.3434	1.28	11907.6520	4.27
2	2	0	12241.6380	1.44	11944.5515	0.03	2	2	0	12506.7518	2.56		
3	0	3	12237.0390	1.41	11908.3330	1.84	3	0	3	12502.9505	0.23	11867.4101	2.26
3	1	3	12242.1158	0.11	11919.8854	0.29	3	1	3	12508.0807	0.02		
3	1	2	12275.2525	1.09	11956.6485	1.63	3	1	2	12541.2133	0.28	11619.8477	2.16
3	2	2	12308.7366	2.66	12013.1104	0.94	3	2	2	12573.7993	0.21		
3	2	1	12314.9064	1.90	12018.4539	2.44	3	2	1	12580.2895	0.16		
3	3	1			12131.6761	1.12	3	3	1	12653.6183	1.11		
3	3	0	12389.5379	2.47	12131.8117	1.44	3	3	0	12653.6753	1.08		
4	0	4	12317.4410	0.86	11991.3823	0.12	4	0	4	12583.5150	1.76	11950.5669	1.69
4	1	4	12319.8861	2.32	11998.3026	1.59	4	1	4	12585.8114	0.77	11958.3170	0.92
4	1	3	12373.5039	1.30	12058.4355	0.47	4	1	3	12639.6856	4.71		
4	2	3	12398.8029	0.81	12105.0072	3.46	4	2	3	12663.8303	1.51	12068.5901	2.26
4	2	2	12414.9307	1.42	12119.6107	1.23	4	2	2	12680.7550	0.10		
4	3	2	12482.7512	1.87	12226.6806	0.40	4	3	2	12747.1397	1.15		
4	3	1	12484.1679	5.37	12227.5731	1.01	4	3	1	12748.5065	1.20		
4	4	1	12590.5817	1.09	12381.1905	2.31	4	4	1	12852.8834	1.21		
4	4	0	12590.6245	2.73	12381.2128	0.18	4	4	0	12852.8839	4.49		
5	0	5	12414.4402	1.77	12091.0914	0.22	5	0	5	12680.0953	0.75		
5	1	5	12415.5176	3.01	12094.9021	0.07	5	1	5	12681.4710	4.66		
5	1	4	12492.3359	2.15	12184.7644	2.80	5	1	4	12758.6388	1.40		
5	2	4	12509.8586	0.64	12218.3638	0.32	5	2	4	12774.4996	1.57		
5	2	3	12541.1514	1.83	12247.9859	1.55	5	2	3	12807.3380	2.17		
5	3	3	12599.3000	2.25	12345.2853	0.08	5	3	3	12864.1122	3.57		
5	3	2	12604.4648	2.39	12348.6528	2.35	5	3	2	12869.3402	0.05		
5	4	2	12707.9683	4.30	12500.1620	1.07	5	4	2	12970.1897	3.23		
5	4	1	12708.2333	0.54	12500.3821	0.23	5	4	1	12970.2582	0.43		
5	5	1	12840.7655	4.31	12687.7778	0.78	5	5	1	13098.8298	4.20		
5	5	0	12840.7919	1.47	12687.7741	0.78	5	5	0	13098.6604	1.73		
6	0	6	12528.1973	3.16	12207.2068	0.27	6	0	6	12794.0588	6.80		
6	1	6	12528.6586	1.12	12209.2605	0.81	6	1	6	12794.6756	0.70		
6	1	5	12629.2601	0.05	12327.8971	0.78	6	2	5	12904.8373	0.65		
6	2	5	12636.5443	0.34	12352.2244	1.20	6	2	4	12959.1463	0.50		
6	2	4	12691.8975	4.44	12403.5167	0.62	6	3	4	13002.5326	1.27		
6	3	4	12738.3230	1.32	12487.2678	14.0	6	4	3	13111.2713	4.24		
6	3	3			12496.1703	2.15							
6	4	3	12848.8889	6.01	12641.9325	1.13	7	0	7	12924.9461	1.19		
6	4	2	12850.2483	8.29	12643.7047	0.98	7	1	7	12925.3294	3.10		
6	5	2	12981.5795	1.85	12831.7410	2.02	7	1	6	13048.9658	1.37		
6	5	1	12981.8051	5.21	12831.7077	4.11	7	3	4	13191.1235	4.25		
7	0	7	12659.0313	0.11	12339.8836	7.02	8	0	8	13073.4208	4.97		
7	1	7			12341.0751	0.15	8	1	8	13071.9939	2.41		
7	2	6	12788.3330	0.68			8	3	6	13347.8218	7.15		
7	2	5	12864.7985	4.79									
7	3	5	12898.8388	1.38			9	1	9	13234.7796	1.73		
7	3	4	12925.5570	0.19	12670.8420	8.58							
7	4	4	13013.1070	2.63	12811.6557	3.07							
7	5	2	13146.5621	4.46									
8	3	6	13081.6564	0.87									

B. In addition to the usual Coriolis, Darling–Dennison, and Fermi resonances, the interactions between (211) and (032), (310) and (131), (310) and (013), and (310) and (032) had to be taken into account.

C. Very complicated mixings of states were found; indeed, there were cases where three or more states were mixed simultaneously:

—the levels (211) [826] at 13 066.4103 cm^{-1}, (310) [836] at 13 081.6564 cm^{-1} and (112) [818] at 13 071.9939 cm^{-1}

—the levels (211) [625] at 12 649.5879 cm^{-1}, (310) [615] at 12 629.2601 cm^{-1} and (131) [643] at 12 641.9325 cm^{-1}.

D. It was necessary to introduce in the energy level calculations the highly excited "dark" states (032), (150), and (051). Indeed, these dark states perturb through resonances the positions of the observed energy levels. They were then introduced in the calculations and some of their Hamiltonian constants were varied during the fit. The so-called HEL (highly excited local) resonances (*4*) were taken into account for the analysis of the perturbations affecting some rotational levels of the (230) and (131) vibrational states; this resonance is due to a coupling between these states and the (080) vibrational state, formally belonging to the 4ν higher polyade. The same situation takes place for the rotational levels of the (310) and (112) states which interact with (160).

IV. CONCLUSION

Using water vapor Fourier-transform spectra recorded between 11 300 and 13 600 cm^{-1}, we have obtained a set of accurate rotational energy levels for six interacting vibrational states belonging to the second decade of $H_2{}^{18}O$. These results improve the knowledge of the $H_2{}^{18}O$ absorption spectrum in the near-infrared region.

ACKNOWLEDGMENT

The research described in this publication was supported in part by Grant N NY3000 from the International Science Foundation.

RECEIVED: December 20, 1994

REFERENCES

1. J.-P. CHEVILLARD, J.-Y. MANDIN, J.-M. FLAUD, AND C. CAMY-PEYRET, *Can. J. Phys.* **64,** 746–761 (1986).
2. J.-P. CHEVILLARD, J.-Y. MANDIN, J.-M. FLAUD, AND C. CAMY-PEYRET, *Can. J. Phys.* **65,** 777–789 (1987).
3. J.-Y. MANDIN, J.-P. CHEVILLARD, J.-M. FLAUD, AND C. CAMY-PEYRET, *Can. J. Phys.* **66,** 997–1011 (1988).
4. A. BYKOV, O. NAUMENKO, AND L. N. SINITSA, *Atm. Opt.* **3,** 1014–1018 (1990).