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INFRARED CO LINE LIST FOR THE $X\ ^1\Sigma^+$ STATE

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ABSTRACT

A complete line list with improved accuracy for all the rotation-vibration transitions of the fundamental, first, and second overtone bands up to $v = 20$ and $J = 149$ of the ground state $X\ ^1\Sigma^+$ of the seven CO isotopes—$^{12}C^{16}O$, $^{13}C^{16}O$, $^{12}C^{17}O$, $^{12}C^{18}O$, $^{13}C^{18}O$, $^{14}C^{16}O$, and $^{13}C^{17}O$—is made available to the astronomical community. A line list of the pure rotational transitions up to $v = 5$ and $J = 60$ is also made available for these seven isotopes. This line list contains the transition frequency, the lower state energy, the Einstein A-value, the gf-value, the transition strength at 3000 K or 1000 K for the pure rotational transitions, the expectation value of the effective dipole moment operator, and the quantum numbers of each transition. Individual partition functions are reported in the temperature range of 500 to 10,000 K. This line list is available as four text files from the author using an anonymous ftp transfer and in computer-readable form in the AAS CD-ROM Series, Vol. 3.

Subject heading: molecular data

1. INTRODUCTION

There is a long history of calculating the intrinsic molecular line parameters for CO (Kirby-Docken & Liu 1978). Two conditions make it necessary to recalculate the intrinsic molecular parameters of CO. The first is the availability of more accurate energy term values, while the second is the reporting of better expectation values of the electric dipole moment operator. Both of these conditions have been met recently with the publication of mass-independent Dunham parameters by Farrenq et al. (1991) and expectation values of the electric dipole moment function by Goorvitch & Chackerian (1994a, b). They have reported rotation-vibration expectation values of the electric dipole moment operator for $v \leq 20$ and $J \leq 149$ for the fundamental, first, and second overtone bands of the $X\ ^1\Sigma^+$ ground state of the seven isotopes of CO centered at approximately 2.5, 1.25, and 0.83 μm. The object of this short note is make available to the general astronomical community an accurate line list for the seven isotopes of CO: $^{12}C^{16}O$, $^{13}C^{16}O$, $^{12}C^{17}O$, $^{12}C^{18}O$, $^{13}C^{18}O$, $^{14}C^{16}O$, and $^{13}C^{17}O$. This line list is available as four text files from the author by sending an e-mail message to the internet address co@cma.arc.nasa.gov or co@128.102.20.45, and in computer-readable form in the AAS CD-ROM Series, Vol. 3.

Because of its large dissociation energy and the relatively high abundance of its constituent atoms, carbon monoxide in its several isotopic forms is observed in a variety of astrophysical sources. Since many of these sources are quite hot, the molecular emissions can be observed from highly excited vibrational levels that may or may not be in local thermodynamic equilibrium. The main isotopic forms, $^{12}C^{16}O$ and $^{13}C^{16}O$, have been observed in a variety of astrophysical sources such as stellar photospheres, comets, and the interstellar medium. The minor isotopic forms $^{12}C^{17}O$, $^{12}C^{18}O$, $^{13}C^{18}O$, and $^{13}C^{17}O$ are also observable in several of these astrophysical sources. The presence of these minor isotopic forms of CO provides evidence of the nuclear processes which occur in the interior of stars.

2. CALCULATION

This CO line list includes the transition frequency in wavenumbers (cm^{-1}), the expectation value of the effective electric dipole matrix operator in D^2 ($debye^2$), the Einstein transition probability or A-value in s^{-1}, the lower state term energy in wavenumbers with the lowest energy level equal to zero, the gf-value, the strength S in cm mol^{-1} evaluated at $T = 3000$ K or 1000 K for the pure rotational transitions, the upper state vibrational quantum number (v'), the lower state vibrational quantum number (v''), the transition type (R or P), the lower state angular momentum number (J''), and the isotopic designation, e.g., 26 for $^{12}C^{16}O$. To remove any ambiguity in the A-value, the gf-value or the strength, I present their definitions. The Einstein A-value is given by

$$A_{v+n,J'\to v,J''} = \frac{64\pi^4\sigma^3}{3h}\langle v+n,\ J'|M(x)|v,\ J''\rangle^2\frac{|m|}{2J'+1}\ , \quad (1)$$

where

$$\frac{64\pi^4}{3h} = 3.136186\times 10^{-7}\ \mathrm{cm^3\ s^{-1}\ D^{-2}}\ ; \quad (2)$$

σ is the frequency of the transition in cm^{-1}; $v \equiv v''$; $n = 0, 1, 2,$ or 3 and denotes the pure rotational or overtone bands, i.e., $v' = v + n$; $M(x)$ is the electric dipole moment function as a function of the reduced internuclear distance x (see Chackerian & Tipping 1983); $m \equiv [J'(J'+1) - J''(J''+1)]/2$; and h is Planck's constant. The single and double primes designate the upper and lower states of the transition, respectively. The transition frequencies, σ, are calculated using the results of Farrenq et al. (1991). These calculated transition frequencies are compared to those observed in the solar spectrum reported by Geller (1992). The frequencies of the highest J-values observed for the R and P branches of the $\Delta v = +1$ series agree to

the second decimal place or better. The transition frequencies calculated with the constants of Authier, Bagland, & Le Floch (1993) agree with those calculated with the constants of Farrenq et al. (1991) for $J \leq 40$. However for higher J the frequencies calculated with the constants of Authier et al. (1993) start to progressively deviate from the transitions measured in the solar spectrum.

The transition moments, $\langle v + n, J' | M(x) | v, J'' \rangle^2$, are calculated using the results of Goorvitch & Chackerian (1994a, b), who used the experimentally derived electric dipole moment function (EDMF) reported by Chackerian et al. (1984). Recently, Huré & Roueff (1993) reported expectation values of the EDMF using an ab initio EDMF. A comparison by Chackerian et al. (1994) of results using the experimentally derived EDMF with those using the ab initio derived EDMF show that the experimentally derived EDMF of Chackerian et al. (1984) is to be preferred.

The emission oscillator strength, $f_{v+n,J' \to v,J''}$, is related to the A-values through

$$g_{J'} f_{v+n,J' \to v,J''} = -\frac{m_e c}{8\pi^2 e^2 \sigma^2} (2J' + 1) A_{v+n,J' \to v,J''}, \quad (3)$$

where $m_e c / 8\pi^2 e^2 = 1.499$ cm^{-2} s (Larsson 1983) and $g_J = 2J + 1$. The absorption oscillator strength, $f_{v+n,J' \leftarrow v,J''}$, is then given by

$$g_{J''} f_{v+n,J' \leftarrow v,J''} = -g_{J'} f_{v+n,J' \to v,J''} = gf . \quad (4)$$

The strength S (cm mol^{-1}) at absolute temperature T is given by

$$S_{v+n,J' \leftarrow v,J''} = \frac{\pi e^2}{m_e c^2} g_{J''} f_{v+n,J' \leftarrow v,J''} \frac{1}{Q(T)} \times \exp\left[-\frac{hcE(v'', J'')}{kT}\right]\left[1 - \exp\left(-\frac{hc\sigma}{kT}\right)\right], \quad (5)$$

where $\pi e^2 / m_e c^2 = 8.8523 \times 10^{-13}$ cm mol^{-1} and $E(v'', J'')$ is the lower state term energy in cm^{-1}. The strength S is related to the optical depth, t_σ, through $dt_\sigma = S\Phi(\sigma - \sigma_0) N ds$, where N is the number density of the radiating species in mol cm^{-3}, ds is the path length differential in cm, and $\Phi(\sigma - \sigma_0)$ is the line shape of the transition centered at σ_0 in cm and is normalized to unity, i.e., $\int \Phi(\sigma - \sigma_0) d\sigma = 1$. The partition function, $Q(T)$, is defined as

$$Q(T) = \sum_{\text{el}} \sum_{v''} \sum_{J''} g_{\text{el}} (2J'' + 1) \exp\left[-\frac{hcE(el, v'', J'')}{kT}\right], \quad (6)$$

"el" indicates summation over the electronic states, $g_{\text{el}} = (2 - \delta_{\Lambda,0})(2S + 1)$ is the degeneracy number of the electronic states given by Sharp (1987), where Λ is the resultant orbital angular momentum about the internuclear axis and S is the resultant spin of the electronic state, and h, c, and k are the usual constants. The lowest energy level of each isotope, $E(0, 0)$, is taken as the zero-point reference for the energy levels. If one uses the minimum point of the potential curve as the reference of zero energy, then the right-hand sides of equations (5) and (6) are multiplied by $\exp(hcE(0, 0)/kT)$. Table 1 presents the value of the lowest energy level for each isotope when the minimum point of the potential curve is the zero reference.

TABLE 1

LOWEST ENERGY LEVELS WHEN THE MINIMUM POINT OF THE POTENTIAL CURVE IS THE ZERO REFERENCE

Isotope	$E(0, 0)$[a]
$^{12}C^{16}O$	1081.5857
$^{13}C^{16}O$	1057.5452
$^{12}C^{17}O$	1067.8459
$^{12}C^{18}O$	1055.5364
$^{13}C^{18}O$	1030.8832
$^{14}C^{16}O$	1036.5699
$^{13}C^{17}O$	1043.4860

[a] Units of wavenumbers (cm^{-1}).

Chackerian, Guelachvili, & Tipping (1983) have given individual partition functions for $^{12}C^{16}O$, $^{13}C^{16}O$, and $^{12}C^{18}O$ isotopes over the temperature range of 100 to 4000 K. I have calculated individual partition functions for the remaining CO isotopes and extended the temperature range to 10,000 K for all seven isotopes. I have fitted individual partition functions for the seven CO isotopes every 100 K from 500 to 10,000 K using the fitting form (Sauval & Tatum 1984)

$$\log Q(T) = \sum_{i=0}^{3} a_i \left(\log \frac{5040}{T}\right)^i . \quad (7)$$

The results of the linear regression fit are given in Table 2. The columns left to right are the isotope designation and the linear regression coefficients a_i. The numbers in parentheses are the standard error estimates for each regression coefficient given in the last significant figures. The coefficient of determination, r^2, is better than 0.999.

These partition functions are calculated by directly summing over the ground state levels plus using approximate formulas for the contribution of the electronic states. The lowest energy level is taken as zero, consistent with equations (5) and (6). Term values of the ground state have been measured directly up to $v = 20$ and $J = 133$ by Farrenq et al. (1991) and

TABLE 2

INDIVIDUAL PARTITION FUNCTIONS

Isotope	a_0[a]	a_1[a]	a_2[a]	a_3[a]
$^{12}C^{16}O$	3.6142(14)[b]	−1.7736(7)[b]	0.4108(34)[b]	0.0176(37)[b]
$^{13}C^{16}O$	3.6409(14)	−1.7796(7)	0.4047(33)	0.0224(35)
$^{12}C^{17}O$	3.6294(14)	−1.7770(7)	0.4073(33)	0.0204(36)
$^{12}C^{18}O$	3.6432(13)	−1.7801(7)	0.4042(32)	0.0228(35)
$^{13}C^{18}O$	3.6713(13)	−1.7863(7)	0.3977(31)	0.0278(34)
$^{14}C^{16}O$	3.6647(13)	−1.7849(7)	0.3992(32)	0.0266(35)
$^{13}C^{17}O$	3.6568(13)	−1.7831(7)	0.4010(32)	0.0253(35)

[a] The coefficients a_i are defined in eq. (7).

[b] Numbers in parentheses are the standard errors of the coefficients a_i estimated in the last significant figures.

TABLE 3

COMPARISON OF CALCULATED PARTITION FUNCTIONS FOR $^{12}C^{16}O$

T(K)	$Q(T)$		
1000	380.3[a]	380.3[b]	380.3[c]
2000	928.3	928.2	928.3
3000	1717.2	1716.6	1717.2
4000	2760.0	2752.9	2760.1
5000	4066.0	4030.1	4066.1
6000	5644.3	5532.0	5644.5
7000	7507.4	7240.6	7507.8
8000	9677.2	9143.8	9676.3
9000	12191.8	11249.2	12187.2

[a] Results reported by Irwin 1987.

[b] Present calculation with summation over ground state levels with $v \leq 41$ and $J \leq 94$.

[c] Present calculation with summation over ground state levels less than 80,000 cm^{-1}.

$v = 41$ and $J = 94$ by Guelachvili et al. (1983). Direct summation over the terms of the ground state for $v \leq 41$ and $J \leq 94$ gave results below the values reported by Irwin (1987) for $^{12}C^{16}O$ at the higher temperatures. Extending the summations to 80,000 cm^{-1} gives results that differ from those reported by Irwin (1987) by no more than 0.038%. These results are for $^{12}C^{16}O$. The contribution of the electronic states to the partition function is calculated using the results of Sharp (1987) for the electronic and vibrational contribution and McDowell (1988) for the rotational contribution. Isotopic effects are accounted for using the formulas of Fäy, Marenin, & van Citters (1971). For temperatures less than 8000 K the contribution of excited electronic states is less than 0.2%. Since Farrenq et al. (1991) have reported mass-independent Dunham coefficients, the summation over term values can be calculated for the different isotopes with confidence. Table 3 reports the present calculation of the partition function for $^{12}C^{16}O$ along with the results of Irwin (1987). The columns left to right are the temperature, the partition function values reported by Irwin (1987), the present calculation with the summation over the observed laboratory levels, (i.e., $v \leq 41$, $J \leq 94$), and the present calculation with the summation extended to 80,000 cm^{-1}. As can be seen from Table 3 there is no practical difference between the results of Irwin (1987) and the present calculations when summation is extended to 80,000 cm^{-1}. Table 4 reports individual isotopic partition functions at several temperatures.

The A-values were compared with the previous calculation of Chackerian & Tipping (1983) by comparing directly the square of the transition moment matrix element, $\langle v + n, J' | M(x) | v, J'' \rangle^2$ (see eq. [1] and Goorvitch & Chackerian 1994a, b). The results of this comparison are given in Table 5, where $\mathcal{R}$ is the ratio of the presently calculated values of $\langle v + n, J' | M(x) | v, J'' \rangle^2$ to those of Chackerian & Tipping (1983). No comparisons could be made for the $^{14}C^{16}O$ and $^{13}C^{17}O$ isotopes since Chackerian & Tipping (1983) did not calculate transition moments for these isotopes. Comparisons with these previous calculations show good agreement for the $\Delta v = +1$ transitions. The comparison for the $\Delta v = +2$ and +3 transitions show differences as large as a factor of 5.65. The primary difference between the present calculations and those previously reported of Chackerian & Tipping (1983) results from my use of a more up-to-date EDMF reported by Chackerian et al. (1984).

TABLE 5

COMPARISON OF TRANSITION MOMENTS WITH THE PREVIOUS CALCULATION OF CHACKERIAN & TIPPING (1983)[a]

ISOTOPE	$\Delta v = v' - v''$		
	+1	+2	+3
$^{12}C^{16}O$	$0.93 \leq \mathcal{R} \leq 1.06$	$0.78 \leq \mathcal{R} \leq 1.05$	$0.96 \leq \mathcal{R} \leq 1.71$
$^{13}C^{16}O$	$0.93 \leq \mathcal{R} \leq 1.07$	$0.86 \leq \mathcal{R} \leq 1.05$	$0.96 \leq \mathcal{R} \leq 5.65$
$^{12}C^{18}O$	$0.93 \leq \mathcal{R} \leq 1.05$	$0.84 \leq \mathcal{R} \leq 1.04$	$0.96 \leq \mathcal{R} \leq 1.30$
$^{13}C^{18}O$	$0.93 \leq \mathcal{R} \leq 1.05$	$0.84 \leq \mathcal{R} \leq 1.04$	$0.96 \leq \mathcal{R} \leq 1.30$
$^{12}C^{17}O$	$0.93 \leq \mathcal{R} \leq 1.05$	$0.84 \leq \mathcal{R} \leq 1.04$	$0.96 \leq \mathcal{R} \leq 3.43$

[a] $\mathcal{R}$ is the ratio of the presently calculated transition moments squared to those of Chackerian & Tipping 1983.

Table 6 reports the transition frequency, the gf-value and the J-value of the bandhead for each of the R-branches of the $^{12}C^{16}O$ overtone bands. The columns from the left are the lower state vibrational quantum number, the frequency, the gf-value, and the J-value for the fundamental, first, and second overtone bands. The values for the other isotopes are similar.

The pure rotational transitions are calculated for $v \leq 5$ and $J \leq 60$ for the seven isotopes. Chackerian & Tipping (1983) have calculated the pure rotational transitions for $v = 0$ up to $J'' = 54$ for the isotopes $^{12}C^{16}O$, $^{13}C^{16}O$, and $^{12}C^{18}O$. A comparison of the presently calculated A-values for the pure rotational transitions for $v = 0$ with the results of Chackerian & Tipping (1983) show deviations increasing from 0.7% to 2.8% with increasing J. The A-values for any of the pure rotational transitions with $v \leq 5$ and $J'' \leq 150$ can be calculated using the expressions developed in the paper by Goorvitch & Chackerian (1994a). The expectation value for the pure rotational

TABLE 4

CALCULATED ISOTOPIC PARTITION FUNCTIONS

T(K)	$Q(T)$						
	$^{12}C^{16}O$	$^{13}C^{16}O$	$^{12}C^{17}O$	$^{12}C^{18}O$	$^{13}C^{18}O$	$^{14}C^{16}O$	$^{13}C^{17}O$
1000	380.3	399.1	390.9	400.8	421.8	416.8	410.8
3000	1717.2	1819.7	1774.8	1828.7	1944.0	1916.5	1883.8
6000	5644.5	6007.5	5848.1	6039.3	6449.0	6351.1	6234.9
9000	12187.2	12992.2	12638.7	13062.8	13972.5	13755.1	13497.0

TABLE 6

TRANSITION FREQUENCIES, gf-VALUES, AND J-VALUES FOR THE BANDHEADS OF THE R-BRANCH OVERTONE BANDS OF $^{12}C^{16}O$

	$\Delta v = v' - v''$								
	+1			+2			+3		
v''	σ[a]	gf	J''	σ[a]	gf	J''	σ[a]	gf	J''
0	2328.3621	1.199(−03)	91	4360.1039	6.503(−06)	51	6417.8126	2.972(−08)	34
1	2298.6615	2.317(−03)	90	4305.4160	1.907(−05)	50	6337.3504	1.278(−07)	34
2	2269.0511	3.357(−03)	89	4250.8728	3.813(−05)	50	6257.0913	3.415(−07)	34
3	2239.5374	4.375(−03)	89	4196.4842	6.194(−05)	49	6177.0627	6.967(−07)	33
4	2210.1256	5.282(−03)	88	4142.2550	9.291(−05)	49	6097.2606	1.290(−06)	33
5	2180.8100	6.121(−03)	87	4088.1802	1.263(−04)	48	6017.6774	2.172(−06)	33
6	2151.5922	6.895(−03)	86	4034.2789	1.677(−04)	48	5938.3342	3.272(−06)	32
7	2122.4784	7.695(−03)	86	3980.5313	2.089(−04)	47	5859.2383	4.871(−06)	32
8	2093.4732	8.355(−03)	85	3926.9711	2.595(−04)	47	5780.3756	6.947(−06)	32
9	2064.5704	8.957(−03)	84	3873.5684	3.150(−04)	47	5701.7606	9.182(−06)	31
10	2035.7712	9.503(−03)	83	3820.3554	3.652(−04)	46	5623.4114	1.228(−05)	31
11	2007.0807	1.011(−02)	83	3767.3102	4.279(−04)	46	5545.3072	1.602(−05)	31
12	1978.5034	1.056(−02)	82	3714.4515	4.828(−04)	45	5467.4548	1.962(−05)	30
13	1950.0322	1.096(−02)	81	3661.7719	5.521(−04)	45	5389.8833	2.458(−05)	30
14	1921.6676	1.130(−02)	80	3609.2742	6.086(−04)	44	5312.5640	3.029(−05)	30
15	1893.4122	1.174(−02)	80	3556.9649	6.828(−04)	44	5235.4979	3.677(−05)	30
16	1865.2721	1.200(−02)	79	3504.8315	7.402(−04)	43	5158.7178	4.228(−05)	29
17	1837.2382	1.221(−02)	78	3452.8935	8.194(−04)	43	5082.1928	5.006(−05)	29
18	1809.3097	1.239(−02)	77	3401.1236	8.785(−04)	42	5005.9194	5.865(−05)	29
19	1781.4856	1.250(−02)	76	3349.5533	9.620(−04)	42	4929.9228	6.538(−05)	28
20	1753.7742	1.274(−02)	76	3298.1462	1.049(−03)	42	4854.1792	7.521(−05)	28

[a] σ in cm^{-1}.

transition of the EDMF, $\langle v, J'|M(x)|v, J''\rangle^2$, is expressible as

$$\langle v, J'|M(x)|v, J''\rangle = \mathcal{M}_v^v(0)\sqrt{F_v^v(m)}\,, \qquad (8)$$

where $\mathcal{M}_v^v(0)$ is the rotationless transition moment and $F_v^v(m)$ is the vibration-rotation interaction factor. For the pure rotational transitions the vibrational-rotation factor was fitted by a fourth-degree polynomial in m, that is

$$\sqrt{F_v^v(m)} = \sum_{i=0}^{4} b_i m^i \qquad (9)$$

(see Goorvitch & Chackerian 1994a for details). The results of these fits are given in Tables 7 and 8. Table 7 gives the rotationless dipole moments, $\mathcal{M}_v^v(0)$, for the pure rotationless transitions. The columns from the left are the vibrational quantum number and the individual rotationless dipole moments in D for each isotope. Table 8 presents the coefficients b_i for calculating the vibration-rotation interaction factor $F_v^v(m)$ using equation (9). The columns in this table from the left are the vibrational quantum number and the individual b_is-values.

Tables 9, 10, and 11 report the $^{12}C^{16}O$ transitions for $J = 0$, 20, 100, and 135 for the $\Delta v = +1$, +2, and +3 series, respectively. The columns in these three tables from the left are the transition frequency in wavenumbers, the expectation value of the effective electric dipole matrix operator squared, in D^2 (debye^2), the Einstein transition probability or A-value in s^{-1}, the lower state term energy in wavenumbers with the lowest energy level equal to zero, the gf-value, the strength S in cm mol^{-1} evaluated at $T = 3000$ K, the upper state vibrational quantum number, the lower state vibrational quantum number, the transition type, and the lower state angular momentum number.

3. CONCLUSION

A detailed line list is made available for the fundamental, first, and second overtone bands of the seven isotopes of CO. Each overtone band for each isotope consists of 6279 lines. A

TABLE 7

ROTATIONLESS DIPOLE MOMENTS, $\mathcal{M}_v^v(0)$, FOR THE PURE ROTATIONAL TRANSITIONS (D)

v	$^{12}C^{16}O$	$^{13}C^{16}O$	$^{12}C^{18}O$	$^{12}C^{17}O$	$^{13}C^{18}O$	$^{14}C^{16}O$	$^{13}C^{17}O$
0	−1.1013(−01)	−1.1046(−01)	−1.1049(−01)	−1.1034(−01)	−1.1079(−01)	−1.1072(−01)	−1.1063(−01)
1	−8.5066(−02)	−8.5962(−02)	−8.6034(−02)	−8.5598(−02)	−8.6906(−02)	−8.6705(−02)	−8.6460(−02)
2	−5.9961(−02)	−6.1420(−02)	−6.1539(−02)	−6.0815(−02)	−6.2987(−02)	−6.2652(−02)	−6.2246(−02)
3	−3.4803(−02)	−3.6824(−02)	−3.6990(−02)	−3.5977(−02)	−3.9017(−02)	−3.8549(−02)	−3.7980(−02)
4	−9.5731(−03)	−1.2160(−02)	−1.2374(−02)	−1.1070(−02)	−1.4984(−02)	−1.4381(−02)	−1.3650(−02)
5	1.5743(−02)	1.2583(−02)	1.2322(−02)	1.3919(−02)	9.1241(−03)	9.8620(−03)	1.0759(−02)

TABLE 8

POLYNOMIAL FITS TO $[F_v^v(m)]^{1/2}$ FOR THE PURE ROTATIONAL TRANSITIONS

	v	b_0	b_1	b_2	b_3	b_4
	0	9.9985(−01)	3.0160(−07)	−1.0290(−04)	−2.8660(−11)	−3.4601(−10)
	1	9.9977(−01)	4.6416(−07)	−1.3444(−04)	−4.3977(−11)	−4.5695(−10)
	2	9.9962(−01)	7.4813(−07)	−1.9250(−04)	−7.0611(−11)	−6.6399(−10)
$^{12}C^{16}O$	3	9.9928(−01)	1.4233(−06)	−3.3484(−04)	−1.3512(−10)	−1.1744(−09)
	4	9.9708(−01)	5.7174(−06)	−1.2291(−03)	−5.4066(−10)	−4.3959(−09)
	5	1.0019(+00)	−3.7325(−06)	7.5483(−04)	3.5320(−10)	2.7554(−09)
	0	9.9987(−01)	2.5741(−07)	−9.8086(−05)	−2.4411(−11)	−3.1307(−10)
	1	9.9980(−01)	3.9347(−07)	−1.2718(−04)	−3.7146(−11)	−4.0979(−10)
	2	9.9969(−01)	6.1584(−07)	−1.7963(−04)	−5.8459(−11)	−5.8671(−10)
$^{13}C^{16}O$	3	9.9941(−01)	1.1558(−06)	−3.0241(−04)	−1.0949(−10)	−1.0042(−09)
	4	9.9806(−01)	3.7555(−06)	−9.2451(−04)	−3.5750(−10)	−3.1266(−09)
	5	1.0020(+00)	−3.8879(−06)	9.0214(−04)	3.6948(−10)	3.1101(−09)
	0	9.9986(−01)	2.7374(−07)	−1.0012(−04)	−2.6081(−11)	−3.2678(−10)
	1	9.9979(−01)	4.2142(−07)	−1.3023(−04)	−3.9897(−11)	−4.2931(−10)
	2	9.9966(−01)	6.7247(−07)	−1.8499(−04)	−6.3716(−11)	−6.1864(−10)
$^{12}C^{17}O$	3	9.9936(−01)	1.2453(−06)	−3.1564(−04)	−1.1867(−10)	−1.0740(−09)
	4	9.9773(−01)	4.4298(−06)	−1.0357(−03)	−4.1983(−10)	−3.5904(−09)
	5	1.0020(+00)	−3.9610(−06)	8.3184(−04)	3.7230(−10)	2.9397(−09)
	0	9.9987(−01)	2.5687(−07)	−9.7692(−05)	−2.4272(−11)	−3.1044(−10)
	1	9.9981(−01)	3.8095(−07)	−1.2659(−04)	−3.6228(−11)	−4.0606(−10)
	2	9.9969(−01)	6.0926(−07)	−1.7860(−04)	−5.7794(−11)	−5.8064(−10)
$^{12}C^{18}O$	3	9.9943(−01)	1.1663(−06)	−2.9990(−04)	−1.0907(−10)	−9.9115(−10)
	4	9.9813(−01)	3.6897(−06)	−9.0506(−04)	−3.5024(−10)	−3.0460(−09)
	5	1.0020(+00)	−4.0260(−06)	9.1766(−04)	3.7948(−10)	3.1482(−09)
	0	9.9989(−01)	2.1471(−07)	−9.2936(−05)	−2.0285(−11)	−2.7973(−10)
	1	9.9984(−01)	3.2283(−07)	−1.1952(−04)	−3.0452(−11)	−3.6261(−10)
	2	9.9975(−01)	5.0476(−07)	−1.6639(−04)	−4.7852(−11)	−5.1100(−10)
$^{13}C^{18}O$	3	9.9954(−01)	9.2930(−07)	−2.7106(−04)	−8.7252(−11)	−8.4506(−10)
	4	9.9868(−01)	2.4668(−06)	−7.1239(−04)	−2.3671(−10)	−2.2594(−09)
	5	1.0023(+00)	−4.5311(−06)	1.1810(−03)	4.2817(−10)	3.8151(−09)
	0	9.9989(−01)	2.2374(−07)	−9.4023(−05)	−2.1197(−11)	−2.8658(−10)
	1	9.9983(−01)	3.3107(−07)	−1.2113(−04)	−3.1410(−11)	−3.7225(−10)
	2	9.9973(−01)	5.2917(−07)	−1.6914(−04)	−4.9829(−11)	−5.2635(−10)
$^{14}C^{16}O$	3	9.9952(−01)	9.6356(−07)	−2.7742(−04)	−9.0805(−11)	−8.7676(−10)
	4	9.9858(−01)	2.8130(−06)	−7.5059(−04)	−2.6438(−10)	−2.4134(−09)
	5	1.0022(+00)	−4.4582(−)06	1.1050(−03)	4 .1824(−10)	3.6191(−09)
	0	9.9988(−01)	2.3688(−07)	−9.5351(−05)	−2.2327(−11)	−2.9511(−10)
	1	9.9982(−01)	3.5194(−07)	−1.2310(−04)	−3.3336(−11)	−3.8427(−10)
	2	9.9972(−01)	5.5019(−07)	−1.7254(−04)	−5.2165(−11)	−5.4557(−10)
$^{13}C^{17}O$	3	9.9949(−01)	1.0554(−06)	−2.8538(−04)	−9.8520(−11)	−9.1673(−10)
	4	9.9843(−01)	3.1079(−06)	−8.0156(−04)	−2.9403(−10)	−2.6206(−09)
	5	1.0022(+00)	−4.1677(−06)	1.0267(−03)	3.9603(−10)	3.4211(−09)

NOTE.—The coefficients b_i are defined in eq. (9).

TABLE 9

LINE LIST OF $^{12}C^{16}O$ $\Delta v = +1$ TRANSITIONS

σ	R^2	A	E(v'' J'')	gf	S	v'	v''	type	J''	σ	R^2	A	E(v'' J'')	gf	S	v'	v''	type	J''
cm^{-1}	D^2	Hz	cm^{-1}		cm/molecule					cm^{-1}	D^2	Hz	cm^{-1}		cm/molecule				
944.3333	2.798(−01)	3.709(+01)	64722.5752	1.677(−02)	1.041(−31)	21	20	P	135	1450.1033	9.684(−02)	4.654(+01)	32009.3643	6.602(−03)	3.673(−25)	8	7	P	100
964.6793	2.674(−01)	3.778(+01)	63393.7106	1.637(−02)	1.955(−31)	20	19	P	135	1472.6596	8.467(−02)	4.262(+01)	30200.9409	5.862(−03)	7.846(−25)	7	6	P	100
985.0890	2.544(−01)	3.828(+01)	62039.5983	1.590(−02)	3.696(−31)	19	18	P	135	1495.2934	7.252(−02)	3.821(+01)	28366.3694	5.098(−03)	1.662(−24)	6	5	P	100
1005.5666	2.415(−01)	3.864(+01)	60660.1760	1.541(−02)	7.052(−31)	18	17	P	135	1518.0033	6.039(−02)	3.329(+01)	26505.5749	4.310(−03)	3.466(−24)	5	4	P	100
1026.1157	2.280(−01)	3.877(+01)	59255.3776	1.485(−02)	1.354(−30)	17	16	P	135	1540.7876	4.829(−02)	2.784(+01)	24618.4838	3.498(−03)	7.024(−24)	4	3	P	100
1046.7392	2.146(−01)	3.873(+01)	57825.1335	1.425(−02)	2.621(−30)	16	15	P	135	1558.5716	2.219(−01)	1.351(+02)	38576.6231	3.251(−03)	8.145(−27)	21	20	P	20
1067.4396	2.010(−01)	3.848(+01)	56369.3713	1.362(−02)	5.109(−30)	15	14	P	135	1563.6446	3.620(−02)	2.181(+01)	22705.0248	2.661(−03)	1.351(−23)	3	2	P	100
1088.2189	1.873(−01)	3.799(+01)	54888.0162	1.294(−02)	1.002(−29)	14	13	P	135	1582.8651	2.125(−01)	1.355(+02)	36931.0393	3.162(−03)	1.762(−26)	20	19	P	20
1109.0787	1.736(−01)	3.727(+01)	53380.9918	1.222(−02)	1.979(−29)	13	12	P	135	1586.5722	2.413(−02)	1.519(+01)	20765.1284	1.800(−03)	2.339(−23)	2	1	P	100
1130.0201	1.599(−01)	3.631(+01)	51848.2200	1.147(−02)	3.928(−29)	12	11	P	135	1607.2421	2.028(−01)	1.354(+02)	35260.3801	3.065(−03)	3.845(−26)	19	18	P	20
1151.0438	1.462(−01)	3.509(+01)	50289.6222	1.068(−02)	7.834(−29)	11	10	P	135	1609.5683	1.206(−02)	7.927(+00)	18798.7272	9.128(−04)	3.076(−23)	1	0	P	100
1164.2360	2.540(−01)	6.316(+01)	53175.4284	1.390(−02)	2.576(−29)	21	20	P	100	1631.0344	2.170(−01)	9.844(+01)	37917.0909	1.664(−04)	5.895(−28)	21	20	R	0
1172.1504	1.326(−01)	3.360(+01)	48705.1189	9.862(−03)	1.568(−28)	10	9	P	135	1631.7033	1.930(−01)	1.349(+02)	33564.5613	2.961(−03)	8.463(−26)	18	17	P	20
1185.7484	2.425(−01)	6.370(+01)	51699.6990	1.352(−02)	5.154(−29)	20	19	P	100	1656.0615	2.081(−01)	9.880(+01)	36264.1752	1.620(−04)	1.281(−27)	20	19	R	0
1193.3399	1.190(−01)	3.183(+01)	47094.6307	9.012(−03)	3.143(−28)	9	8	P	135	1656.2490	1.831(−01)	1.338(+02)	31843.4982	2.851(−03)	1.878(−25)	17	16	P	20
1207.3354	2.307(−01)	6.400(+01)	50198.8523	1.310(−02)	1.040(−28)	19	18	P	100	1664.7655	1.727(−01)	1.245(+02)	64722.5752	1.838(−02)	1.723(−31)	21	20	R	135
1214.6120	1.055(−01)	2.975(+01)	45458.0782	8.131(−03)	6.298(−28)	8	7	P	135	1680.8794	1.730(−01)	1.321(+02)	30097.1061	2.734(−03)	4.202(−25)	16	15	P	20
1228.9994	2.189(−01)	6.403(+01)	48672.8133	1.264(−02)	2.114(−28)	18	17	P	100	1681.1725	1.989(−01)	9.879(+01)	34586.1834	1.572(−04)	2.806(−27)	19	18	R	0
1235.9662	9.205(−02)	2.735(+01)	43795.3826	7.220(−03)	1.258(−27)	7	6	P	135	1685.6921	2.129(−01)	1.562(+02)	38576.6231	3.543(−03)	9.349(−27)	21	20	R	20
1250.7424	2.068(−01)	6.378(+01)	47121.5049	1.216(−02)	4.334(−28)	17	16	P	100	1694.8390	1.697(−01)	1.291(+02)	63393.7106	1.839(−02)	3.298(−31)	20	19	R	135
1257.4018	7.869(−02)	2.462(+01)	42106.4659	6.280(−03)	2.490(−27)	6	5	P	135	1705.5943	1.628(−01)	1.299(+02)	28325.3003	2.610(−03)	9.474(−25)	15	14	P	20
1272.5657	1.947(−01)	6.324(+01)	45544.8484	1.165(−02)	8.956(−28)	16	15	P	100	1706.3680	1.896(−01)	9.846(+01)	32883.0311	1.521(−04)	6.204(−27)	18	17	R	0
1278.9177	6.542(−02)	2.154(+01)	40391.2511	5.310(−03)	4.851(−27)	5	4	P	135	1711.4172	2.045(−01)	1.570(+02)	36931.0393	3.455(−03)	2.027(−26)	20	19	R	20
1294.4704	1.825(−01)	6.239(+01)	43942.7635	1.111(−02)	1.864(−27)	15	14	P	100	1724.9636	1.658(−01)	1.329(+02)	62039.5983	1.828(−02)	6.350(−31)	19	18	R	135
1300.5126	5.221(−02)	1.808(+01)	38649.6626	4.310(−03)	9.189(−27)	4	3	P	135	1730.3932	1.524(−01)	1.270(+02)	26527.9968	2.480(−03)	2.152(−24)	14	13	P	20
1316.4573	1.703(−01)	6.123(+01)	42315.1695	1.054(−02)	3.908(−27)	14	13	P	100	1731.6483	1.800(−01)	9.771(+01)	31154.6333	1.465(−04)	1.383(−26)	17	16	R	0
1322.1850	3.908(−02)	1.422(+01)	36881.6266	3.279(−03)	1.652(−26)	3	2	P	135	1737.2259	1.958(−01)	1.572(+02)	35260.3801	3.358(−03)	4.431(−26)	19	18	R	20
1338.5266	1.580(−01)	5.973(+01)	40661.9850	9.945(−03)	8.246(−27)	13	12	P	100	1739.4979	1.926(−01)	1.581(+02)	53175.4284	1.590(−02)	3.898(−29)	21	20	R	100
1343.9332	2.600(−02)	9.935(+00)	35087.0708	2.218(−03)	2.673(−26)	2	1	P	135	1755.1445	1.614(−01)	1.364(+02)	60660.1760	1.812(−02)	1.233(−30)	18	17	R	135
1360.6786	1.458(−01)	5.787(+01)	38983.1285	9.325(−03)	1.750(−26)	12	11	P	100	1755.2754	1.420(−01)	1.235(+02)	24705.1121	2.344(−03)	4.919(−24)	13	12	P	20
1365.7550	1.298(−02)	5.205(+00)	33265.9252	1.125(−03)	3.286(−26)	1	0	P	135	1757.0135	1.703(−01)	9.657(+01)	29400.9052	1.407(−04)	3.107(−26)	16	15	R	0
1382.9128	1.335(−01)	5.565(+01)	37278.5186	8.680(−03)	3.732(−26)	11	10	P	100	1763.1190	1.868(−01)	1.568(+02)	33564.5613	3.252(−03)	9.772(−26)	18	17	R	20
1405.2289	1.213(−01)	5.303(+01)	35548.0746	8.011(−03)	7.988(−26)	10	9	P	100	1768.1119	1.870(−01)	1.613(+02)	51699.6990	1.570(−02)	7.890(−29)	20	19	R	100
1427.6261	1.090(−01)	5.000(+01)	33791.7162	7.318(−03)	1.713(−25)	9	8	P	100	1780.2401	1.315(−01)	1.193(+02)	22856.5636	2.202(−03)	1.131(−23)	12	11	P	20

TABLE 9—*Continued*

σ	R^2	A	E(v'' J'')	gf	S	v'	v''	type	J''	σ	R^2	A	E(v'' J'')	gf	S	v'	v''	type	J''
cm^{-1}	D^2	Hz	cm^{-1}		cm/molecule					cm^{-1}	D^2	Hz	cm^{-1}		cm/molecule				
1782.4634	1.605(−01)	9.500(+01)	27621.7621	1.345(−04)	7.035(−26)	15	14	R	0	1968.2849	1.143(−01)	1.362(+02)	50289.6222	1.438(−02)	1.519(−28)	11	10	R	135
1785.3860	1.562(−01)	1.389(+02)	59255.3776	1.783(−02)	2.407(−30)	17	16	R	135	1970.4972	1.354(−01)	1.617(+02)	40661.9850	1.267(−02)	1.356(−26)	13	12	R	100
1789.0967	1.777(−01)	1.558(+02)	31843.4982	3.138(−03)	2.173(−25)	17	16	R	20	1973.2910	1.090(−01)	1.282(+02)	19082.1499	2.123(−03)	7.103(−23)	10	9	R	20
1796.7959	1.809(−01)	1.637(+02)	50198.8523	1.543(−02)	1.610(−28)	19	18	R	100	1982.7754	4.486(−02)	5.624(+01)	7134.7700	8.364(−04)	8.644(−21)	4	3	P	20
1805.2863	1.209(−01)	1.144(+02)	20982.2696	2.053(−03)	2.615(−23)	11	10	P	20	1989.0128	7.750(−02)	6.375(+01)	12463.7686	7.247(−05)	5.825(−23)	7	6	R	0
1807.9975	1.505(−01)	9.297(+01)	25817.1199	1.279(−04)	1.604(−25)	14	13	R	0	1999.0268	1.057(−01)	1.319(+02)	48705.1189	1.351(−02)	3.080(−28)	10	9	R	135
1815.1593	1.683(−01)	1.542(+02)	30097.1061	3.017(−03)	4.870(−25)	16	15	R	20	1999.7252	1.266(−01)	1.580(+02)	38983.1285	1.203(−02)	2.904(−26)	12	11	R	100
1815.6922	1.505(−01)	1.408(+02)	57825.1335	1.748(−02)	4.733(−30)	16	15	R	135	1999.9303	9.858(−02)	1.208(+02)	17156.1253	1.946(−03)	1.654(−22)	9	8	R	20
1825.5527	1.743(−01)	1.655(+02)	48672.8133	1.511(−02)	3.309(−28)	18	17	R	100	2008.4215	3.373(−02)	4.395(+01)	5051.7432	6.369(−04)	1.801(−20)	3	2	P	20
1830.4127	1.103(−01)	1.088(+02)	19082.1499	1.898(−03)	6.066(−23)	10	9	P	20	2015.1815	6.668(−02)	5.705(+01)	10452.2222	6.317(−05)	1.343(−22)	6	5	R	0
1833.6151	1.404(−01)	9.046(+01)	23986.8951	1.210(−04)	3.683(−25)	13	12	R	0	2026.6473	8.808(−02)	1.123(+02)	15204.1184	1.762(−03)	3.849(−22)	8	7	R	20
1841.3066	1.588(−01)	1.519(+02)	28325.3003	2.887(−03)	1.100(−24)	15	14	R	20	2029.0336	1.176(−01)	1.532(+02)	37278.5186	1.133(−02)	6.248(−26)	11	10	R	100
1846.0663	1.443(−01)	1.419(+02)	56369.3713	1.704(−02)	9.370(−30)	15	14	R	135	2029.8448	9.674(−02)	1.264(+02)	47094.6307	1.256(−02)	6.252(−28)	9	8	R	135
1854.3848	1.673(−01)	1.664(+02)	47121.5049	1.473(−02)	6.855(−28)	17	16	R	100	2034.1352	2.254(−02)	3.051(+01)	2942.3028	4.311(−04)	3.379(−20)	2	1	P	20
1855.6181	9.955(−02)	1.023(+02)	17156.1253	1.737(−03)	1.410(−22)	9	8	P	20	2041.4229	5.578(−02)	4.961(+01)	8414.4693	5.353(−05)	3.047(−22)	5	4	R	0
1859.3153	1.301(−01)	8.745(+01)	22131.0050	1.138(−04)	8.506(−25)	12	11	R	0	2053.4404	7.747(−02)	1.027(+02)	13226.0530	1.571(−03)	8.926(−22)	7	6	R	20
1867.5382	1.491(−01)	1.488(+02)	26527.9968	2.750(−03)	2.503(−24)	14	13	R	20	2058.4218	1.082(−01)	1.472(+02)	35548.0746	1.057(−02)	1.349(−25)	10	9	R	100
1876.5107	1.375(−01)	1.419(+02)	54888.0162	1.650(−02)	1.865(−29)	14	13	R	135	2059.9147	1.130(−02)	1.588(+01)	806.3828	2.188(−04)	4.811(−20)	1	0	P	20
1880.9009	8.874(−02)	9.497(+01)	15204.1184	1.569(−03)	3.276(−22)	8	7	P	20	2060.7387	8.739(−02)	1.195(+02)	45458.0782	1.151(−02)	1.268(−27)	8	7	R	135
1883.2941	1.599(−01)	1.666(+02)	45544.8484	1.430(−02)	1.431(−27)	16	15	R	100	2067.7353	4.479(−02)	4.139(+01)	6350.4391	4.354(−05)	6.719(−22)	4	3	R	0
1885.0970	1.198(−01)	8.390(+01)	20249.3682	1.062(−04)	1.974(−24)	11	10	R	0	2080.3080	6.674(−02)	9.203(+01)	11221.8547	1.371(−03)	2.052(−21)	6	5	R	20
1893.8533	1.393(−01)	1.449(+02)	24705.1121	2.604(−03)	5.731(−24)	13	12	R	20	2087.8891	9.852(−02)	1.399(+02)	33791.7162	9.767(−03)	2.917(−25)	9	8	R	100
1906.2597	7.787(−02)	8.675(+01)	13226.0530	1.396(−03)	7.586(−22)	7	6	P	20	2091.7080	7.768(−02)	1.111(+02)	43795.3826	1.039(−02)	2.562(−27)	7	6	R	135
1907.0277	1.302(−01)	1.411(+02)	53380.9918	1.588(−02)	3.735(−29)	13	12	R	135	2094.1169	3.371(−02)	3.236(+01)	4260.0622	3.319(−05)	1.406(−21)	3	2	R	0
1910.9590	1.094(−01)	7.980(+01)	18341.9044	9.827(−05)	4.600(−24)	10	9	R	0	2107.2485	5.589(−02)	8.010(+01)	9191.4507	1.163(−03)	4.645(−21)	5	4	R	20
1912.2820	1.521(−01)	1.659(+02)	43942.7635	1.381(−02)	3.008(−27)	15	14	R	100	2117.4346	8.860(−02)	1.312(+02)	32009.3643	8.908(−03)	6.306(−25)	8	7	R	100
1920.2513	1.293(−01)	1.402(+02)	22856.5636	2.452(−03)	1.320(−23)	12	11	R	20	2120.5661	2.255(−02)	2.248(+01)	2143.2711	2.248(−05)	2.648(−21)	2	1	R	0
1931.6928	6.693(−02)	7.759(+01)	11221.8547	1.216(−03)	1.742(−21)	6	5	P	20	2122.7519	6.761(−02)	1.010(+02)	42106.4659	9.176(−03)	5.131(−27)	6	5	R	135
1936.8999	9.885(−02)	7.509(+01)	16408.5346	9.001(−05)	1.074(−23)	9	8	R	0	2134.2602	4.493(−02)	6.690(+01)	7134.7700	9.467(−04)	1.022(−20)	4	3	R	20
1937.6187	1.225(−01)	1.392(+02)	51848.2200	1.517(−02)	7.518(−29)	12	11	R	135	2147.0571	7.842(−02)	1.211(+02)	30200.9409	7.995(−03)	1.358(−24)	7	6	R	100
1941.3495	1.439(−01)	1.643(+02)	42315.1695	1.327(−02)	6.367(−27)	14	13	R	100	2147.0811	1.131(−02)	1.170(+01)	0.0000	1.142(−05)	3.786(−21)	1	0	R	0
1946.7309	1.192(−01)	1.347(+02)	20982.2696	2.291(−03)	3.057(−23)	11	10	R	20	2153.8693	5.720(−02)	8.930(+01)	40391.2511	7.878(−03)	1.011(−26)	5	4	R	135
1957.1986	5.593(−02)	6.744(+01)	9191.4507	1.029(−03)	3.936(−21)	5	4	P	20	2161.3412	3.385(−02)	5.235(+01)	5051.7432	7.223(−04)	2.132(−20)	3	2	R	20
1962.9184	8.822(−02)	6.975(+01)	14449.1813	8.141(−05)	2.505(−23)	8	7	R	0	2176.7551	6.798(−02)	1.094(+02)	28366.3694	7.026(−03)	2.900(−24)	6	5	R	100
										2185.0587	4.645(−02)	7.571(+01)	38649.6626	6.490(−03)	1.936(−26)	4	3	R	135

TABLE 9—*Continued*

σ	R^2	A	$E(v'' J'')$	gf	S	v'	v''	type	J''
cm^{-1}	D^2	Hz	cm^{-1}		cm/molecule				
2188.4899	2.267(−02)	3.639(+01)	2942.3028	4.898(−04)	4.004(−20)	2	1	R	20
2206.5271	5.729(−02)	9.603(+01)	26505.5749	6.002(−03)	6.094(−24)	5	4	R	100
2215.7044	1.138(−02)	1.897(+01)	806.3828	2.490(−04)	5.710(−20)	1	0	R	20
2216.3185	3.536(−02)	6.014(+01)	36881.6266	5.010(−03)	3.518(−26)	3	2	R	135
2236.3713	4.634(−02)	8.088(+01)	24618.4838	4.921(−03)	1.244(−23)	4	3	R	100
2247.6467	2.392(−02)	4.243(+01)	35087.0708	3.437(−03)	5.753(−26)	2	1	R	135
2266.2858	3.514(−02)	6.382(+01)	22705.0248	3.781(−03)	2.412(−23)	3	2	R	100
2279.0410	1.214(−02)	2.244(+01)	33265.9252	1.768(−03)	7.143(−26)	1	0	R	135
2296.2686	2.368(−02)	4.474(+01)	20765.1284	2.582(−03)	4.206(−23)	2	1	R	100
2326.3174	1.197(−02)	2.352(+01)	18798.7272	1.322(−03)	5.570(−23)	1	0	R	100

NOTE.—See text for explanation of columns.

TABLE 10

LINE LIST OF $^{12}C^{16}O$ $\Delta v = +2$ TRANSITIONS

σ	R^2	A	E(v'' J'')	gf	S	v'	v''	type	J''	σ	R^2	A	E(v'' J'')	gf	S	v'	v''	type	J''
cm^{-1}	D^2	Hz	cm^{-1}		cm/molecule					cm^{-1}	D^2	Hz	cm^{-1}		cm/molecule				
2227.7206	1.264(−02)	2.200(+01)	64722.5752	1.787(−03)	2.000(−32)	22	20	P	135	3113.3569	2.291(−03)	1.090(+01)	35548.0746	3.353(−04)	5.287(−27)	11	9	P	100
2273.1979	1.116(−02)	2.064(+01)	63393.7106	1.610(−03)	3.447(−32)	21	19	P	135	3116.7408	1.163(−04)	5.540(−01)	35087.0708	2.300(−05)	4.526(−28)	3	1	P	135
2318.7916	9.826(−03)	1.928(+01)	62039.5983	1.446(−03)	5.990(−32)	20	18	P	135	3154.9526	1.238(−02)	6.252(+01)	38576.6231	3.672(−04)	1.362(−27)	22	20	P	20
2364.5113	8.611(−03)	1.792(+01)	60660.1760	1.292(−03)	1.048(−31)	19	17	P	135	3159.9428	1.727(−02)	8.514(+01)	59255.3776	3.489(−03)	6.388(−31)	18	16	R	135
2410.3650	7.521(−03)	1.658(+01)	59255.3776	1.151(−03)	1.850(−31)	18	16	P	135	3161.5873	1.847(−03)	9.196(+00)	33791.7162	2.745(−04)	1.011(−26)	10	8	P	100
2456.3598	6.536(−03)	1.525(+01)	57825.1335	1.019(−03)	3.285(−31)	17	15	P	135	3161.6345	2.116(−02)	1.043(+02)	53175.4284	3.176(−03)	1.074(−29)	22	20	R	100
2502.5014	5.649(−03)	1.393(+01)	56369.3713	8.972(−04)	5.871(−31)	16	14	P	135	3165.0787	3.815(−05)	1.904(−01)	33265.9252	7.664(−06)	3.636(−28)	2	0	P	135
2548.7947	4.847(−03)	1.263(+01)	54888.0162	7.840(−04)	1.054(−30)	15	13	P	135	3204.1554	1.113(−02)	5.891(+01)	36931.0393	3.354(−04)	2.758(−27)	21	19	P	20
2593.4798	1.141(−02)	3.136(+01)	53175.4284	1.391(−03)	4.289(−30)	22	20	P	100	3209.9780	1.455(−03)	7.585(+00)	32009.3643	2.196(−04)	1.915(−26)	9	7	P	100
2595.2434	4.124(−03)	1.135(+01)	53380.9918	6.793(−04)	1.899(−30)	14	12	P	135	3215.2273	1.918(−02)	9.946(+01)	51699.6990	2.928(−03)	2.023(−29)	21	19	R	100
2639.9654	1.016(−02)	2.947(+01)	51699.6990	1.262(−03)	7.964(−30)	21	19	P	100	3215.6301	1.535(−02)	7.975(+01)	57825.1335	3.156(−03)	1.156(−30)	17	15	R	135
2641.8504	3.460(−03)	1.004(+01)	51848.2200	5.801(−04)	3.412(−30)	13	11	P	135	3234.0138	1.325(−02)	4.687(+01)	37917.0909	2.015(−05)	1.037(−28)	22	20	R	0
2686.5951	9.024(−03)	2.758(+01)	50198.8523	1.140(−03)	1.491(−29)	20	18	P	100	3253.5242	9.972(−03)	5.524(+01)	35260.3801	3.051(−04)	5.626(−27)	20	18	P	20
2688.6179	2.884(−03)	8.820(+00)	50289.6222	4.920(−04)	6.164(−30)	12	10	P	135	3258.5267	1.114(−03)	6.076(+00)	30200.9409	1.707(−04)	3.565(−26)	8	6	P	100
2733.3744	7.967(−03)	2.564(+01)	48672.8133	1.024(−03)	2.808(−29)	19	17	P	100	3268.9586	1.731(−02)	9.434(+01)	50198.8523	2.686(−03)	3.840(−29)	20	18	R	100
2735.5471	2.369(−03)	7.632(+00)	48705.1189	4.113(−04)	1.111(−29)	11	9	P	135	3271.4545	1.355(−02)	7.411(+01)	56369.3713	2.834(−03)	2.101(−30)	16	14	R	135
2780.3078	7.010(−03)	2.374(+01)	47121.5049	9.162(−04)	5.331(−29)	18	16	P	100	3280.6414	1.431(−02)	7.737(+01)	38576.6231	4.634(−04)	1.748(−27)	22	20	R	20
2782.6386	1.912(−03)	6.483(+00)	47094.6307	3.376(−04)	1.991(−29)	10	8	P	135	3283.9502	1.194(−02)	4.420(+01)	36264.1752	1.843(−05)	2.109(−28)	21	19	R	0
2827.3989	6.132(−03)	2.184(+01)	45544.8484	8.151(−04)	1.018(−28)	17	15	P	100	3303.0609	8.894(−03)	5.155(+01)	33564.5613	2.762(−04)	1.156(−26)	19	17	P	20
2829.8924	1.510(−03)	5.384(+00)	45458.0782	2.711(−04)	3.532(−29)	9	7	P	135	3307.2310	8.224(−04)	4.688(+00)	28366.3694	1.279(−04)	6.478(−26)	7	5	P	100
2874.6505	5.332(−03)	1.996(+01)	43942.7635	7.206(−04)	1.956(−28)	16	14	P	100	3322.8349	1.556(−02)	8.905(+01)	48672.8133	2.454(−03)	7.342(−29)	19	17	R	100
2877.3076	1.159(−03)	4.346(+00)	43795.3826	2.117(−04)	6.170(−29)	8	6	P	135	3327.4213	1.187(−02)	6.831(+01)	54888.0162	2.525(−03)	3.835(−30)	15	13	R	135
2922.0644	4.598(−03)	1.808(+01)	42315.1695	6.316(−04)	3.771(−28)	15	13	P	100	3331.2759	1.291(−02)	7.307(+01)	36931.0393	4.244(−04)	3.547(−27)	21	19	R	20
2924.8829	8.586(−04)	3.381(+00)	42106.4659	1.594(−04)	1.052(−28)	7	5	P	135	3334.0533	1.071(−02)	4.149(+01)	34586.1834	1.678(−05)	4.320(−28)	20	18	R	0
2938.4110	2.620(−02)	1.039(+02)	64722.5752	4.923(−03)	6.341(−32)	22	20	R	135	3352.7664	7.879(−03)	4.776(+01)	31843.4982	2.484(−04)	2.388(−26)	18	16	P	20
2969.6418	3.929(−03)	1.621(+01)	40661.9850	5.485(−04)	7.289(−28)	14	12	P	100	3356.0880	5.776(−04)	3.441(+00)	26505.5749	9.113(−05)	1.134(−25)	6	4	P	100
2972.6166	6.056(−04)	2.504(+00)	40391.2511	1.142(−04)	1.730(−28)	6	4	P	135	3376.8611	1.389(−02)	8.348(+01)	47121.5049	2.228(−03)	1.412(−28)	18	16	R	100
2993.6300	2.377(−02)	9.964(+01)	63393.7106	4.550(−03)	1.118(−31)	21	19	R	135	3382.0764	1.159(−02)	6.867(+01)	35260.3801	3.870(−04)	7.249(−27)	20	18	R	20
3017.3832	3.348(−03)	1.449(+01)	38983.1285	4.749(−04)	1.422(−27)	13	11	P	100	3383.5352	1.030(−02)	6.234(+01)	53380.9918	2.228(−03)	7.021(−30)	14	12	R	135
3020.5061	3.978(−04)	1.726(+00)	38649.6626	7.627(−05)	2.681(−28)	5	3	P	135	3384.3248	9.554(−03)	3.872(+01)	32883.0311	1.520(−05)	8.908(−28)	19	17	R	0
3048.9514	2.148(−02)	9.510(+01)	62039.5983	4.186(−03)	1.985(−31)	20	18	R	135	3402.6412	6.936(−03)	4.395(+01)	30097.1061	2.219(−04)	4.958(−26)	17	15	P	20
3065.2885	2.790(−03)	1.267(+01)	37278.5186	4.021(−04)	2.746(−27)	12	10	P	100	3405.0944	3.787(−04)	2.357(+00)	24618.4838	6.063(−05)	1.875(−25)	5	3	P	100
3068.5487	2.354(−04)	1.070(+00)	36881.6266	4.584(−05)	3.789(−28)	4	2	P	135	3431.0414	1.233(−02)	7.772(+01)	45544.8484	2.009(−03)	2.729(−28)	17	15	R	100
3104.3859	1.932(−02)	9.028(+01)	60660.1760	3.834(−03)	3.551(−31)	19	17	R	135	3433.0448	1.035(−02)	6.411(+01)	33564.5613	3.506(−04)	1.490(−26)	19	17	R	20

TABLE 10—*Continued*

σ	R^2	A	E(v'' J'')	gf	S	v'	v''	type	J''	σ	R^2	A	E(v'' J'')	gf	S	v'	v''	type	J''
cm^{-1}	D^2	Hz	cm^{-1}		cm/molecule					cm^{-1}	D^2	Hz	cm^{-1}		cm/molecule				
3434.7657	8.476(−03)	3.591(+01)	31154.6333	1.369(−05)	1.848(−27)	18	16	R	0	3759.4777	4.972(−03)	4.122(+01)	35548.0746	8.875(−04)	1.507(−26)	11	9	R	100
3439.7994	8.857(−03)	5.632(+01)	51848.2200	1.948(−03)	1.289(−29)	13	11	R	135	3780.6247	2.421(−03)	2.044(+01)	42106.4659	5.852(−04)	4.287(−28)	7	5	R	135
3452.6852	6.056(−03)	4.009(+01)	28325.3003	1.966(−04)	1.033(−25)	16	14	P	20	3792.5608	2.855(−03)	1.628(+01)	18341.9044	5.091(−06)	3.327(−25)	11	9	R	0
3454.2466	2.230(−04)	1.449(+00)	22705.0248	3.622(−05)	2.820(−25)	4	2	P	100	3794.5452	3.786(−03)	3.168(+01)	20982.2696	1.418(−04)	2.613(−24)	12	10	R	20
3484.1821	9.192(−03)	5.954(+01)	31843.4982	3.162(−04)	3.086(−26)	18	16	R	20	3807.6250	1.679(−03)	1.490(+01)	15204.1184	6.009(−05)	1.771(−23)	9	7	P	20
3485.3764	7.472(−03)	3.307(+01)	29400.9052	1.224(−05)	3.856(−27)	17	15	R	0	3814.7802	4.064(−03)	3.520(+01)	33791.7162	7.361(−04)	2.918(−26)	10	8	R	100
3485.3790	1.086(−02)	7.177(+01)	43942.7635	1.798(−03)	5.297(−28)	16	14	R	100	3837.9667	1.734(−03)	1.531(+01)	40391.2511	4.254(−04)	7.132(−28)	6	4	R	135
3496.2165	7.510(−03)	5.014(+01)	50289.6222	1.679(−03)	2.360(−29)	12	10	R	135	3844.3288	2.310(−03)	1.372(+01)	16408.5346	4.175(−06)	6.929(−25)	10	8	R	0
3502.8978	5.247(−03)	3.627(+01)	26527.9968	1.728(−04)	2.163(−25)	15	13	P	20	3846.8506	3.128(−03)	2.727(+01)	19082.1499	1.188(−04)	5.471(−24)	11	9	R	20
3503.5410	1.090(−04)	7.389(−01)	20765.1284	1.796(−05)	3.565(−25)	3	1	P	100	3858.9663	1.286(−03)	1.189(+01)	13226.0530	4.667(−05)	3.568(−23)	8	6	P	20
3535.4889	8.114(−03)	5.492(+01)	30097.1061	2.832(−04)	6.423(−26)	17	15	R	20	3870.2410	3.247(−03)	2.937(+01)	32009.3643	5.967(−04)	5.588(−26)	9	7	R	100
3536.1566	6.537(−03)	3.022(+01)	27621.7621	1.087(−05)	8.078(−27)	16	14	R	0	3895.4577	1.159(−03)	1.071(+01)	38649.6626	2.887(−04)	1.122(−27)	5	3	R	135
3539.8760	9.498(−03)	6.574(+01)	42315.1695	1.596(−03)	1.033(−27)	15	13	R	100	3896.2532	1.826(−03)	1.129(+01)	14449.1813	3.345(−06)	1.427(−24)	9	7	R	0
3552.7882	6.273(−03)	4.395(+01)	48705.1189	1.425(−03)	4.309(−29)	11	9	R	135	3899.3155	2.536(−03)	2.303(+01)	17156.1253	9.761(−05)	1.137(−23)	10	8	R	20
3552.9733	3.553(−05)	2.511(−01)	18798.7272	5.935(−06)	3.042(−25)	2	0	P	100	3910.4580	9.493(−04)	9.129(+00)	11221.8547	3.490(−05)	7.010(−23)	7	5	P	20
3553.2779	4.502(−03)	3.248(+01)	24705.1121	1.504(−04)	4.537(−25)	14	12	P	20	3925.8580	2.521(−03)	2.380(+01)	30200.9409	4.700(−04)	1.053(−25)	8	6	R	100
3586.9651	7.112(−03)	5.027(+01)	28325.3003	2.519(−04)	1.343(−25)	16	14	R	20	3948.3311	1.402(−03)	9.019(+00)	12463.7686	2.602(−06)	2.890(−24)	8	6	R	0
3587.1057	5.671(−03)	2.736(+01)	25817.1199	9.563(−06)	1.698(−26)	15	13	R	0	3951.9372	2.008(−03)	1.898(+01)	15204.1184	7.835(−05)	2.339(−23)	9	7	R	20
3594.5340	8.227(−03)	5.962(+01)	40661.9850	1.404(−03)	2.019(−27)	14	12	R	100	3953.0947	6.970(−04)	6.727(+00)	36881.6266	1.762(−04)	1.606(−27)	4	2	R	135
3603.8239	3.820(−03)	2.876(+01)	22856.5636	1.295(−04)	9.527(−25)	13	11	P	20	3962.0968	6.662(−04)	6.664(+00)	9191.4507	2.482(−05)	1.326(−22)	6	4	P	20
3609.5151	5.146(−03)	3.781(+01)	47094.6307	1.188(−03)	7.821(−29)	10	8	R	135	3981.6285	1.887(−03)	1.859(+01)	28366.3694	3.567(−04)	1.936(−25)	7	5	R	100
3638.2224	4.871(−03)	2.452(+01)	23986.8951	8.332(−06)	3.578(−26)	14	12	R	0	4000.5592	1.036(−03)	6.936(+00)	10452.2222	1.949(−06)	5.705(−24)	7	5	R	0
3638.6101	6.179(−03)	4.559(+01)	26527.9968	2.219(−04)	2.818(−25)	15	13	R	20	4004.7127	1.544(−03)	1.519(+01)	13226.0530	6.105(−05)	4.727(−23)	8	6	R	20
3649.3537	7.062(−03)	5.356(+01)	38983.1285	1.224(−03)	3.959(−27)	13	11	R	100	4010.8743	3.484(−04)	3.512(+00)	35087.0708	8.935(−05)	1.936(−27)	3	1	R	135
3654.5341	3.197(−03)	2.509(+01)	20982.2696	1.098(−04)	1.997(−24)	12	10	P	20	4013.8793	4.359(−04)	4.533(+00)	7134.7700	1.645(−05)	2.366(−22)	5	3	P	20
3666.3973	4.128(−03)	3.179(+01)	45458.0782	9.676(−04)	1.405(−28)	9	7	R	135	4037.5497	1.344(−03)	1.381(+01)	26505.5749	2.577(−04)	3.429(−25)	6	4	R	100
3689.5052	4.130(−03)	2.168(+01)	22131.0050	7.163(−06)	7.531(−26)	13	11	R	0	4052.9343	7.284(−04)	5.069(+00)	8414.4693	1.388(−06)	1.084(−23)	6	4	R	0
3690.4229	5.315(−03)	4.091(+01)	24705.1121	1.936(−04)	5.924(−25)	14	12	R	20	4057.6387	1.144(−03)	1.170(+01)	11221.8547	4.582(−05)	9.317(−23)	7	5	R	20
3704.3351	5.971(−03)	4.736(+01)	37278.5186	1.050(−03)	7.738(−27)	12	10	R	100	4065.8022	2.561(−04)	2.768(+00)	5051.7432	9.789(−06)	3.840(−22)	4	2	P	20
3705.4060	2.633(−03)	2.154(+01)	19082.1499	9.172(−05)	4.168(−24)	11	9	P	20	4068.7922	1.162(−04)	1.223(+00)	33265.9252	3.022(−05)	1.575(−27)	2	0	R	135
3723.4343	3.219(−03)	2.596(+01)	43795.3826	7.664(−04)	2.484(−28)	8	6	R	135	4093.6182	8.922(−04)	9.551(+00)	24618.4838	1.734(−04)	5.730(−25)	5	3	R	100
3740.9521	3.461(−03)	1.894(+01)	20249.3682	6.087(−06)	1.586(−25)	12	10	R	0	4105.4531	4.770(−04)	3.451(+00)	6350.4391	9.206(−07)	1.943(−23)	5	3	R	0
3742.4019	4.509(−03)	3.620(+01)	22856.5636	1.666(−04)	1.243(−24)	13	11	R	20	4110.7120	8.058(−04)	8.573(+00)	9191.4507	3.270(−05)	1.768(−22)	6	4	R	20
3756.4373	2.127(−03)	1.813(+01)	17156.1253	7.512(−05)	8.640(−24)	10	8	P	20	4117.8620	1.249(−04)	1.403(+00)	2942.3028	4.836(−06)	5.239(−22)	3	1	P	20
										4149.8303	5.329(−04)	5.942(+00)	22705.0248	1.050(−04)	8.724(−25)	4	2	R	100

TABLE 10—*Continued*

σ cm^{-1}	R^2 D^2	A Hz	E(v'' J'') cm^{-1}	gf	S cm/molecule	v'	v''	type	J''
4158.1121	2.807(−04)	2.109(+00)	4260.0622	5.486(−07)	3.169(−23)	4	2	R	0
4163.9292	5.285(−04)	5.844(+00)	7134.7700	2.173(−05)	3.162(−22)	5	3	R	20
4170.0551	4.057(−05)	4.731(−01)	806.3828	1.591(−06)	4.819(−22)	2	0	P	20
4206.1822	2.653(−04)	3.081(+00)	20765.1284	5.299(−05)	1.121(−24)	3	1	R	100
4210.9080	1.373(−04)	1.072(+00)	2143.2711	2.718(−07)	4.350(−23)	3	1	R	0
4217.2869	3.116(−04)	3.580(+00)	5051.7432	1.297(−05)	5.149(−22)	4	2	R	20
4262.6697	8.786(−05)	1.062(+00)	18798.7272	1.778(−05)	9.700(−25)	2	0	R	100
4263.8372	4.468(−05)	3.621(−01)	0.0000	8.957(−08)	4.022(−23)	2	0	R	0
4270.7816	1.530(−04)	1.825(+00)	2942.3028	6.450(−06)	7.068(−22)	3	1	R	20
4324.4098	4.992(−05)	6.183(−01)	806.3828	2.131(−06)	6.529(−22)	2	0	R	20

NOTE.—See text for explanation of columns.

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TABLE 11

LINE LIST OF $^{12}C^{16}O$ $\Delta v = +3$ TRANSITIONS

σ cm^{-1}	R^2 D^2	A Hz	$E(v'' J'')$ cm^{-1}	gf	S cm/molecule	v'	v''	type	J''	σ cm^{-1}	R^2 D^2	A Hz	$E(v'' J'')$ cm^{-1}	gf	S cm/molecule	v'	v''	type	J''
3486.0233	6.912(−04)	4.608(+00)	64722.5752	1.529(−04)	2.117(−33)	23	20	P	135	4648.4983	1.034(−04)	1.636(+00)	38983.1285	2.259(−05)	7.893(−29)	14	11	P	100
3556.5852	5.906(−04)	4.182(+00)	63393.7106	1.333(−04)	3.517(−33)	22	19	P	135	4671.3923	1.239(−03)	1.973(+01)	56369.3713	3.699(−04)	3.095(−31)	17	14	R	135
3627.3102	5.008(−04)	3.762(+00)	62039.5983	1.153(−04)	5.866(−33)	21	18	P	135	4714.2050	4.232(−06)	6.979(−02)	38649.6626	1.266(−06)	5.211(−30)	6	3	P	135
3698.2139	4.220(−04)	3.359(+00)	60660.1760	9.904(−05)	9.835(−33)	20	17	P	135	4716.0740	1.648(−03)	2.697(+01)	50198.8523	3.689(−04)	5.969(−30)	21	18	R	100
3769.3097	3.524(−04)	2.970(+00)	59255.3776	8.430(−05)	1.653(−32)	19	16	P	135	4721.9930	7.747(−05)	1.285(+00)	37278.5186	1.720(−05)	1.367(−28)	13	10	P	100
3840.6091	2.912(−04)	2.596(+00)	57825.1335	7.097(−05)	2.782(−32)	18	15	P	135	4726.5054	8.142(−04)	1.383(+01)	38576.6231	3.618(−05)	1.543(−28)	23	20	P	20
3912.1220	2.377(−04)	2.240(+00)	56369.3713	5.902(−05)	4.680(−32)	17	14	P	135	4752.8095	1.016(−03)	1.705(+01)	54888.0162	3.088(−04)	5.282(−31)	16	13	R	135
3983.8565	1.914(−04)	1.905(+00)	54888.0162	4.839(−05)	7.856(−32)	16	13	P	135	4788.5422	1.931(−06)	3.336(−02)	36881.6266	5.867(−07)	5.661(−30)	5	2	P	135
3997.8162	6.513(−04)	6.559(+00)	53175.4284	1.224(−04)	4.524(−31)	23	20	P	100	4794.9976	1.402(−03)	2.413(+01)	48672.8133	3.193(−04)	1.079(−29)	20	17	R	100
4055.8191	1.516(−04)	1.592(+00)	53380.9918	3.902(−05)	1.313(−31)	15	12	P	135	4795.7325	5.652(−05)	9.825(−01)	35548.0746	1.274(−05)	2.332(−28)	12	9	P	100
4069.2092	5.558(−04)	5.902(+00)	51699.6990	1.063(−04)	8.020(−31)	22	19	P	100	4800.5364	6.934(−04)	1.234(+01)	36931.0393	3.130(−05)	2.951(−28)	22	19	P	20
4128.0151	1.179(−04)	1.305(+00)	51848.2200	3.088(−05)	2.179(−31)	14	11	P	135	4812.1655	9.258(−04)	1.079(+01)	37917.0909	2.094(−06)	1.231(−29)	23	20	R	0
4140.8121	4.693(−04)	5.251(+00)	50198.8523	9.135(−05)	1.423(−30)	21	18	P	100	4834.4458	8.217(−04)	1.451(+01)	53380.9918	2.540(−04)	8.989(−31)	15	12	R	135
4186.9565	3.267(−03)	3.747(+01)	64722.5752	8.746(−04)	1.291(−32)	23	20	R	135	4850.7623	1.068(−03)	1.867(+01)	38576.6231	5.114(−05)	2.196(−28)	23	20	R	20
4200.4483	8.965(−05)	1.046(+00)	50289.6222	2.390(−05)	3.581(−31)	13	10	P	135	4863.1045	6.951(−07)	1.258(−02)	35087.0708	2.145(−07)	4.914(−30)	4	1	P	135
4212.6341	3.934(−04)	4.635(+00)	48672.8133	7.791(−05)	2.537(−30)	20	17	P	100	4869.7153	3.996(−05)	7.272(−01)	33791.7162	9.148(−06)	3.901(−28)	11	8	P	100
4267.2756	2.835(−03)	3.441(+01)	63393.7106	7.734(−04)	2.171(−32)	22	19	R	135	4874.1433	1.183(−03)	2.137(+01)	47121.5049	2.737(−04)	1.954(−29)	19	16	R	100
4273.1212	6.646(−05)	8.162(−01)	48705.1189	1.802(−05)	5.805(−31)	12	9	P	135	4874.8146	5.864(−04)	1.092(+01)	35260.3801	2.688(−05)	5.669(−28)	21	18	P	20
4284.6828	3.264(−04)	4.046(+00)	47121.5049	6.574(−05)	4.529(−30)	19	16	P	100	4886.9295	7.897(−04)	9.635(+00)	36264.1752	1.814(−06)	2.366(−29)	22	19	R	0
4346.0354	4.780(−05)	6.176(−01)	47094.6307	1.319(−05)	9.240(−31)	11	8	P	135	4916.3069	6.533(−04)	1.213(+01)	51848.2200	2.054(−04)	1.522(−30)	14	11	R	135
4347.7423	2.445(−03)	3.140(+01)	62039.5983	6.798(−04)	3.674(−32)	21	18	R	135	4926.2252	9.131(−04)	1.672(+01)	36931.0393	4.441(−05)	4.214(−28)	22	19	R	20
4356.9644	2.675(−04)	3.486(+00)	45544.8484	5.478(−05)	8.079(−30)	18	15	P	100	4937.8864	1.539(−07)	2.916(−03)	33265.9252	4.822(−08)	2.655(−30)	3	0	P	135
4419.1912	3.315(−05)	4.503(−01)	45458.0782	9.297(−06)	1.435(−30)	10	7	P	135	4943.9392	2.720(−05)	5.180(−01)	32009.3643	6.322(−06)	6.362(−28)	10	7	P	100
4428.3737	2.092(−03)	2.839(+01)	60660.1760	5.924(−04)	6.238(−32)	20	17	R	135	4949.3431	4.900(−04)	9.555(+00)	33564.5613	2.280(−05)	1.089(−27)	20	17	P	20
4429.4838	2.163(−04)	2.962(+00)	43942.7635	4.503(−05)	1.439(−29)	17	14	P	100	4953.5177	9.866(−04)	1.871(+01)	45544.8484	2.321(−04)	3.542(−29)	18	15	R	100
4492.5880	2.198(−05)	3.137(−01)	43795.3826	6.267(−06)	2.158(−30)	9	6	P	135	4961.9419	6.678(−04)	8.528(+00)	34586.1834	1.558(−06)	4.559(−29)	21	18	R	0
4502.2445	1.722(−04)	2.477(+00)	42315.1695	3.645(−05)	2.554(−29)	16	13	P	100	4998.3973	5.094(−04)	9.940(+00)	50289.6222	1.628(−04)	2.559(−30)	13	10	R	135
4509.1843	1.775(−03)	2.542(+01)	59255.3776	5.117(−04)	1.062(−31)	19	16	R	135	5001.9351	7.729(−04)	1.481(+01)	35260.3801	3.816(−05)	8.100(−28)	21	18	R	20
4558.8575	2.215(−03)	3.275(+01)	53175.4284	4.796(−04)	1.844(−30)	23	20	R	100	5018.4013	1.768(−05)	3.521(−01)	30200.9409	4.171(−06)	1.003(−27)	9	6	P	100
4566.2243	1.378(−05)	2.064(−01)	42106.4659	3.992(−06)	3.104(−30)	8	5	P	135	5024.1240	4.050(−04)	8.261(+00)	31843.4982	1.913(−05)	2.093(−27)	19	16	P	20
4575.2489	1.348(−04)	2.034(+00)	40661.9850	2.899(−05)	4.508(−29)	15	12	P	100	5033.1263	8.133(−04)	1.618(+01)	43942.7635	1.944(−04)	6.422(−29)	17	14	R	100
4590.1869	1.491(−03)	2.253(+01)	57825.1335	4.376(−04)	1.813(−31)	18	15	R	135	5037.2056	5.591(−04)	7.470(+00)	32883.0311	1.324(−06)	8.803(−29)	20	17	R	0
4637.3639	1.916(−03)	2.982(+01)	51699.6990	4.220(−04)	3.309(−30)	22	19	R	100	5077.8953	6.488(−04)	1.301(+01)	33564.5613	3.253(−05)	1.563(−27)	20	17	R	20
4640.0977	8.025(−06)	1.262(−01)	40391.2511	2.363(−06)	4.201(−30)	7	4	P	135	5080.7198	3.882(−04)	7.955(+00)	48705.1189	1.261(−04)	4.254(−30)	12	9	R	135

TABLE 11—*Continued*

σ cm^{-1}	R^2 D^2	A Hz	E(v'' J'') cm^{-1}	gf	S cm/molecule	v'	v''	type	J''	σ cm^{-1}	R^2 D^2	A Hz	E(v'' J'') cm^{-1}	gf	S cm/molecule	v'	v''	type	J''
5093.0982	1.085(−05)	2.258(−01)	28366.3694	2.597(−06)	1.510(−27)	8	5	P	100	5538.9714	1.731(−04)	4.506(+00)	22856.5636	9.466(−06)	7.877(−26)	14	11	R	20
5099.1585	3.307(−04)	7.051(+00)	30097.1061	1.585(−05)	4.021(−27)	18	15	P	20	5554.6538	6.864(−05)	1.892(+00)	19082.1499	3.585(−06)	1.824(−25)	12	9	P	20
5112.7226	4.631(−04)	6.470(+00)	31154.6333	1.113(−06)	1.701(−28)	19	16	R	0	5571.1419	1.097(−04)	1.983(+00)	20249.3682	2.873(−07)	8.355(−27)	13	10	R	0
5112.9729	6.615(−04)	1.380(+01)	42315.1695	1.606(−04)	1.162(−28)	16	13	R	100	5579.5551	3.174(−05)	8.613(−01)	38649.6626	1.132(−05)	4.844(−29)	6	3	R	135
5154.1079	5.390(−04)	1.130(+01)	31843.4982	2.743(−05)	3.018(−27)	19	16	R	20	5597.1321	1.253(−04)	3.428(+00)	32009.3643	3.330(−05)	3.444(−27)	10	7	R	100
5163.2764	2.879(−04)	6.191(+00)	47094.6307	9.504(−05)	6.967(−30)	11	8	R	135	5616.6958	1.305(−04)	3.543(+00)	20982.2696	7.238(−06)	1.484(−25)	13	10	R	20
5168.0256	6.175(−06)	1.343(−01)	26505.5749	1.500(−06)	2.137(−27)	7	4	P	100	5631.4306	4.852(−05)	1.394(+00)	17156.1253	2.569(−06)	3.301(−25)	11	8	P	20
5174.4469	2.663(−04)	5.935(+00)	28325.3003	1.296(−05)	7.714(−27)	17	14	P	20	5648.4159	8.025(−05)	1.512(+00)	18341.9044	2.131(−07)	1.552(−26)	12	9	R	0
5188.4938	3.790(−04)	5.534(+00)	29400.9052	9.244(−07)	3.287(−28)	18	15	R	0	5663.4938	1.542(−05)	4.376(−01)	36881.6266	5.584(−06)	5.594(−29)	5	2	R	135
5193.0605	5.298(−04)	1.158(+01)	40661.9850	1.306(−04)	2.097(−28)	15	12	R	100	5678.6644	8.504(−05)	2.430(+00)	30200.9409	2.293(−05)	5.661(−27)	9	6	R	100
5230.5742	4.424(−04)	9.697(+00)	30097.1061	2.285(−05)	5.829(−27)	18	15	R	20	5694.6649	9.598(−05)	2.715(+00)	19082.1499	5.396(−06)	2.759(−25)	12	9	R	20
5243.1790	3.177(−06)	7.218(−02)	24618.4838	7.832(−07)	2.767(−27)	6	3	P	100	5708.4442	3.308(−05)	9.896(−01)	15204.1184	1.775(−06)	5.833(−25)	10	7	P	20
5246.0676	2.066(−04)	4.660(+00)	45458.0782	6.928(−05)	1.117(−29)	10	7	R	135	5725.9306	5.700(−05)	1.119(+00)	16408.5346	1.534(−07)	2.831(−26)	11	8	R	0
5249.9887	2.113(−04)	4.917(+00)	26527.9968	1.043(−05)	1.475(−26)	16	13	P	20	5747.6505	5.970(−06)	1.771(−01)	35087.0708	2.194(−06)	5.212(−29)	4	1	R	135
5264.5195	3.060(−04)	4.668(+00)	27621.7621	7.574(−07)	6.343(−28)	17	14	R	0	5760.4294	5.477(−05)	1.634(+00)	28366.3694	1.498(−05)	8.940(−27)	8	5	R	100
5273.3905	4.168(−04)	9.538(+00)	38983.1285	1.044(−04)	3.761(−28)	14	11	R	100	5772.8751	6.852(−05)	2.019(+00)	17156.1253	3.905(−06)	5.042(−25)	11	8	R	20
5307.2946	3.585(−04)	8.207(+00)	28325.3003	1.878(−05)	1.124(−26)	17	14	R	20	5785.6904	2.158(−05)	6.722(−01)	13226.0530	1.174(−06)	9.986(−25)	9	6	P	20
5318.5534	1.412(−06)	3.347(−02)	22705.0248	3.530(−07)	3.132(−27)	5	2	P	100	5803.6820	3.906(−05)	7.983(−01)	14449.1813	1.066(−07)	5.045(−26)	10	7	R	0
5325.7825	1.648(−04)	4.003(+00)	24705.1121	8.250(−06)	2.806(−26)	15	12	P	20	5832.0198	1.438(−06)	4.455(−02)	33265.9252	5.361(−07)	3.058(−29)	3	0	R	135
5329.0929	1.423(−04)	3.365(+00)	43795.3826	4.849(−05)	1.742(−29)	9	6	R	135	5842.4231	3.294(−05)	1.025(+00)	26505.5749	9.139(−06)	1.335(−26)	7	4	R	100
5340.7988	2.434(−04)	3.877(+00)	25817.1199	6.112(−07)	1.220(−27)	16	13	R	0	5851.3225	4.723(−05)	1.449(+00)	15204.1184	2.728(−06)	9.004(−25)	10	7	R	20
5353.9636	3.214(−04)	7.696(+00)	37278.5186	8.169(−05)	6.689(−28)	13	10	R	100	5863.1646	1.333(−05)	4.321(−01)	11221.8547	7.349(−07)	1.638(−24)	8	5	P	20
5384.2686	2.862(−04)	6.841(+00)	26527.9968	1.521(−05)	2.163(−26)	16	13	R	20	5881.6659	2.564(−05)	5.454(−01)	12463.7686	7.090(−08)	8.718(−26)	9	6	R	0
5394.1431	4.941(−07)	1.222(−02)	20765.1284	1.253(−07)	2.827(−27)	4	1	P	100	5924.6407	1.804(−05)	5.854(−01)	24618.4838	5.075(−06)	1.837(−26)	6	3	R	100
5401.8264	1.260(−04)	3.193(+00)	22856.5636	6.398(−06)	5.296(−26)	14	11	P	20	5930.0027	3.119(−05)	9.960(−01)	13226.0530	1.826(−06)	1.560(−24)	9	6	R	20
5412.3510	9.312(−05)	2.307(+00)	42106.4659	3.222(−05)	2.611(−29)	8	5	R	135	5940.8620	7.666(−06)	2.585(−01)	9191.4507	4.282(−07)	2.534(−24)	7	4	P	20
5417.3305	1.904(−04)	3.165(+00)	23986.8951	4.850(−07)	2.336(−27)	15	12	R	0	5959.8775	1.594(−05)	3.529(−01)	10452.2222	4.467(−08)	1.445(−25)	8	5	R	0
5434.7792	2.419(−04)	6.059(+00)	35548.0746	6.243(−05)	1.176(−27)	12	9	R	100	6007.0772	8.604(−06)	2.910(−01)	22705.0248	2.454(−06)	2.229(−26)	5	2	R	100
5461.4948	2.247(−04)	5.607(+00)	24705.1121	1.212(−05)	4.142(−26)	15	12	R	20	6008.9110	1.952(−05)	6.486(−01)	11221.8547	1.158(−06)	2.593(−24)	8	5	R	20
5469.9422	1.062(−07)	2.738(−03)	18798.7272	2.730(−08)	1.586(−27)	3	0	P	100	6018.7775	4.002(−06)	1.403(−01)	7134.7700	2.265(−07)	3.602(−24)	6	3	P	20
5478.1179	9.420(−05)	2.491(+00)	20982.2696	4.852(−06)	9.897(−26)	13	10	P	20	6038.3121	9.239(−06)	2.126(−01)	8414.4693	2.623(−08)	2.259(−25)	7	4	R	0
5494.1124	1.461(−04)	2.533(+00)	22131.0050	3.773(−07)	4.439(−27)	14	11	R	0	6088.0427	1.139(−05)	3.937(−01)	9191.4507	6.846(−07)	4.068(−24)	7	4	R	20
5495.8395	5.695(−05)	1.477(+00)	40391.2511	2.001(−05)	3.702(−29)	7	4	R	135	6089.7267	3.267(−06)	1.151(−01)	20765.1284	9.447(−07)	2.181(−26)	4	1	R	100
5515.8361	1.771(−04)	4.636(+00)	33791.7162	4.637(−05)	2.034(−27)	11	8	R	100	6096.9061	1.815(−06)	6.617(−02)	5051.7432	1.041(−07)	4.504(−24)	5	2	P	20

TABLE 11—*Continued*

σ	R^2	A	E(v'' J'')	gf	S	v'	v''	type	J''
cm^{-1}	D^2	Hz	cm^{-1}		cm/molecule				
6116.9646	4.865(−06)	1.164(−01)	6350.4391	1.399(−08)	3.250(−25)	6	3	R	0
6167.3927	6.044(−06)	2.172(−01)	7134.7700	3.680(−07)	5.876(−24)	6	3	R	20
6172.5834	7.713(−07)	2.830(−02)	18798.7272	2.261(−07)	1.343(−26)	3	0	R	100
6175.2426	6.540(−07)	2.477(−02)	2942.3028	3.797(−08)	4.529(−24)	4	1	P	20
6195.8300	2.228(−06)	5.539(−02)	4260.0622	6.489(−09)	4.117(−25)	5	2	R	0
6246.9560	2.791(−06)	1.042(−01)	5051.7432	1.721(−07)	7.479(−24)	5	2	R	20
6253.7819	1.461(−07)	5.746(−03)	806.3828	8.589(−09)	2.859(−24)	3	0	P	20
6274.9032	8.114(−07)	2.096(−02)	2143.2711	2.394(−09)	4.199(−25)	4	1	R	0
6326.7274	1.026(−06)	3.978(−02)	2942.3028	6.406(−08)	7.670(−24)	4	1	R	20
6354.1791	1.835(−07)	4.921(−03)	0.0000	5.481(−10)	2.693(−25)	3	0	R	0
6406.7016	2.341(−07)	9.431(−03)	806.3828	1.481(−08)	4.949(−24)	3	0	R	20

NOTE.—See text for explanation of columns.

TABLE 12

BEGINNING LINE LIST OF THE PURE ROTATIONAL TRANSITIONS

σ	R^2	A	E(v'' J'')	gf	S	v'	v''	type	J''	isotope
cm^{-1}	D^2	Hz	cm^{-1}		cm/molecule					
3.3413	8.383(−05)	3.269(−10)	9978.5056	1.317(−10)	7.714(−34)	5	5	R	0	38
3.3716	2.236(−04)	8.960(−10)	8030.6787	3.544(−10)	3.454(−32)	4	4	R	0	38
3.3775	9.790(−05)	3.943(−10)	10031.7165	1.554(−10)	8.629(−34)	5	5	R	0	46
3.4019	1.520(−03)	6.256(−09)	6058.9737	2.431(−09)	4.079(−30)	3	3	R	0	38
3.4083	2.059(−04)	8.523(−10)	8073.7764	3.299(−10)	3.091(−32)	4	4	R	0	46
3.4217	1.165(−04)	4.879(−10)	10096.4045	1.874(−10)	9.740(−34)	5	5	R	0	37
3.4322	3.964(−03)	1.675(−08)	4063.3308	6.396(−09)	1.912(−28)	2	2	R	0	38
3.4391	1.484(−03)	6.309(−09)	6091.6946	2.399(−09)	3.928(−30)	3	3	R	0	46
3.4531	1.854(−04)	7.982(−10)	8126.1738	3.010(−10)	2.688(−32)	4	4	R	0	37
3.4625	7.548(−03)	3.276(−08)	2043.6919	1.229(−08)	6.774(−27)	1	1	R	0	38
3.4699	3.922(−03)	1.713(−08)	4085.4105	6.397(−09)	1.895(−28)	2	2	R	0	46
3.4845	1.440(−03)	6.370(−09)	6131.4792	2.359(−09)	3.750(−30)	3	3	R	0	37
3.4928	1.227(−02)	5.465(−08)	0.0000	2.015(−08)	2.120(−25)	0	0	R	0	38
3.4993	1.527(−04)	6.841(−10)	10209.0426	2.512(−10)	1.164(−33)	5	5	R	0	28
3.5007	7.513(−03)	3.370(−08)	2054.8649	1.236(−08)	6.863(−27)	1	1	R	0	46
3.5124	1.593(−04)	7.214(−10)	10227.8102	2.630(−10)	1.195(−33)	5	5	R	0	36
3.5159	3.871(−03)	1.759(−08)	4112.2588	6.398(−09)	1.875(−28)	2	2	R	0	37
3.5315	1.225(−02)	5.642(−08)	0.0000	2.034(−08)	2.191(−25)	0	0	R	0	46
3.5318	1.523(−04)	7.013(−10)	8217.4219	2.528(−10)	2.076(−32)	4	4	R	0	28
3.5451	1.470(−04)	6.848(−10)	8232.6269	2.450(−10)	1.984(−32)	4	4	R	0	36
3.5473	7.471(−03)	3.486(−08)	2068.4520	1.246(−08)	6.971(−27)	1	1	R	0	37
3.5644	1.366(−03)	6.466(−09)	6200.7707	2.289(−09)	3.452(−30)	3	3	R	0	28
3.5778	1.354(−03)	6.480(−09)	6212.3181	2.277(−09)	3.404(−30)	3	3	R	0	36
3.5788	1.223(−02)	5.862(−08)	0.0000	2.058(−08)	2.278(−25)	0	0	R	0	37
3.5795	1.948(−04)	9.342(−10)	10324.0086	3.279(−10)	1.350(−33)	5	5	R	0	27
3.5969	3.783(−03)	1.841(−08)	4159.0249	6.397(−09)	1.838(−28)	2	2	R	0	28
3.6105	3.769(−03)	1.854(−08)	4166.8191	6.397(−09)	1.831(−28)	2	2	R	0	36
3.6132	1.217(−04)	6.003(−10)	8310.5703	2.068(−10)	1.557(−32)	4	4	R	0	27
3.6294	7.397(−03)	3.697(−08)	2092.1217	1.262(−08)	7.158(−27)	1	1	R	0	28
3.6432	7.385(−03)	3.733(−08)	2096.0669	1.265(−08)	7.189(−27)	1	1	R	0	36

NOTES.—See text for explanation of columns. Table 12 is published in its entirety in computer-readable form in the AAS CD-ROM Series, Vol. 3.

TABLE 13

BEGINNING LINE LIST OF THE FUNDAMENTAL TRANSITIONS

σ	R^2	A	E(v'' J'')	gf	S	v'	v''	type	J''	isotope
cm^{-1}	D^2	Hz	cm^{-1}		cm/molecule					
849.8039	2.928(−01)	2.827(+01)	69999.5215	1.743(−02)	7.914(−33)	21	20	P	149	26
856.6729	2.918(−01)	2.886(+01)	69612.2062	1.739(−02)	9.572(−33)	21	20	P	148	26
857.0984	2.876(−01)	2.849(+01)	68948.3033	1.727(−02)	1.265(−32)	21	20	P	149	27
862.2408	2.837(−01)	2.862(+01)	68159.3991	1.714(−02)	1.796(−32)	21	20	P	149	36
863.2127	2.832(−01)	2.866(+01)	68005.3522	1.712(−02)	1.925(−32)	21	20	P	149	28
863.5241	2.908(−01)	2.946(+01)	69226.4014	1.735(−02)	1.157(−32)	21	20	P	147	26
863.7689	2.867(−01)	2.907(+01)	68567.4004	1.723(−02)	1.524(−32)	21	20	P	148	27
868.7648	2.828(−01)	2.918(+01)	67783.3560	1.709(−02)	2.159(−32)	21	20	P	148	36
868.8127	2.784(−01)	2.873(+01)	67081.4706	1.694(−02)	2.895(−32)	21	20	P	149	37
869.7017	2.801(−01)	2.899(+01)	68742.5046	1.706(−02)	1.443(−32)	20	19	P	149	26
869.7083	2.822(−01)	2.921(+01)	67630.2615	1.708(−02)	2.312(−32)	21	20	P	148	28
870.3576	2.899(−01)	3.007(+01)	68842.1295	1.732(−02)	1.397(−32)	21	20	P	146	26
870.4223	2.857(−01)	2.965(+01)	68188.0212	1.719(−02)	1.836(−32)	21	20	P	147	27
871.8550	2.760(−01)	2.878(+01)	66550.9300	1.686(−02)	3.662(−32)	21	20	P	149	46
874.2649	2.739(−01)	2.879(+01)	66114.3966	1.677(−02)	4.438(−32)	21	20	P	149	38
875.1398	2.775(−01)	2.927(+01)	66712.1271	1.690(−02)	3.467(−32)	21	20	P	148	37
875.2721	2.819(−01)	2.974(+01)	67408.8446	1.705(−02)	2.593(−32)	21	20	P	147	36
876.1873	2.813(−01)	2.977(+01)	67256.7040	1.703(−02)	2.774(−32)	21	20	P	147	28
876.5652	2.750(−01)	2.914(+01)	67690.8352	1.689(−02)	2.302(−32)	20	19	P	149	27
876.6022	2.791(−01)	2.959(+01)	68349.7991	1.703(−02)	1.749(−32)	20	19	P	148	26
877.0585	2.848(−01)	3.023(+01)	67810.1872	1.714(−02)	2.208(−32)	21	20	P	146	27
877.1731	2.889(−01)	3.068(+01)	68459.4130	1.727(−02)	1.685(−32)	21	20	P	145	26
878.0864	2.751(−01)	2.931(+01)	66184.9088	1.681(−02)	4.377(−32)	21	20	P	148	46
880.4184	2.730(−01)	2.931(+01)	65751.1194	1.672(−02)	5.297(−32)	21	20	P	148	38
881.3870	2.714(−01)	2.923(+01)	66901.9690	1.675(−02)	3.267(−32)	20	19	P	149	36
881.4507	2.766(−01)	2.981(+01)	66344.3238	1.685(−02)	4.148(−32)	21	20	P	147	37
881.7625	2.810(−01)	3.031(+01)	67035.8856	1.700(−02)	3.111(−32)	21	20	P	146	36
882.2966	2.706(−01)	2.924(+01)	66747.9649	1.672(−02)	3.497(−32)	20	19	P	149	28
882.6496	2.803(−01)	3.033(+01)	66884.7001	1.698(−02)	3.327(−32)	21	20	P	146	28
883.2664	2.741(−01)	2.972(+01)	67304.7549	1.684(−02)	2.780(−32)	20	19	P	148	27

NOTES.—See text for explanation of columns. Table 13 is published in its entirety in computer-readable form in the AAS CD-ROM Series, Vol. 3.

TABLE 14

BEGINNING LINE LIST OF THE FIRST OVERTONE TRANSITIONS

σ	R^2	A	$E(v'' J'')$	gf	S	v'	v''	type	J''	isotope
cm^{-1}	D^2	Hz	cm^{-1}		cm/molecule					
2061.6780	1.358(−02)	1.873(+01)	69999.5215	1.962(−03)	1.671(−33)	22	20	P	149	26
2070.4999	1.298(−02)	1.812(+01)	68948.3033	1.882(−03)	2.575(−33)	22	20	P	149	27
2073.9149	1.351(−02)	1.896(+01)	69612.2062	1.949(−03)	2.006(−33)	22	20	P	148	26
2076.4018	1.254(−02)	1.766(+01)	68159.3991	1.823(−03)	3.558(−33)	22	20	P	149	36
2077.4854	1.248(−02)	1.761(+01)	68005.3522	1.816(−03)	3.799(−33)	22	20	P	149	28
2082.3256	1.291(−02)	1.834(+01)	68567.4004	1.870(−03)	3.082(−33)	22	20	P	148	27
2083.4875	1.199(−02)	1.706(+01)	67081.4706	1.750(−03)	5.543(−33)	22	20	P	149	37
2086.0935	1.343(−02)	1.918(+01)	69226.4014	1.936(−03)	2.406(−33)	22	20	P	147	26
2086.5613	1.172(−02)	1.675(+01)	66550.9300	1.713(−03)	6.886(−33)	22	20	P	149	46
2087.9257	1.247(−02)	1.786(+01)	67783.3560	1.812(−03)	4.248(−33)	22	20	P	148	36
2088.8914	1.150(−02)	1.650(+01)	66114.3966	1.683(−03)	8.229(−33)	22	20	P	149	38
2088.9511	1.241(−02)	1.781(+01)	67630.2615	1.804(−03)	4.532(−33)	22	20	P	148	28
2094.0955	1.284(−02)	1.855(+01)	68188.0212	1.858(−03)	3.685(−33)	22	20	P	147	27
2094.6082	1.193(−02)	1.725(+01)	66712.1271	1.739(−03)	6.596(−33)	22	20	P	148	37
2097.4874	1.166(−02)	1.694(+01)	66184.9088	1.702(−03)	8.181(−33)	22	20	P	148	46
2098.2141	1.336(−02)	1.941(+01)	68842.1295	1.923(−03)	2.884(−33)	22	20	P	146	26
2099.3956	1.241(−02)	1.807(+01)	67408.8446	1.801(−03)	5.068(−33)	22	20	P	147	36
2099.6591	1.145(−02)	1.668(+01)	65751.1194	1.673(−03)	9.764(−33)	22	20	P	148	38
2100.3630	1.235(−02)	1.800(+01)	67256.7040	1.793(−03)	5.403(−33)	22	20	P	147	28
2105.6772	1.187(−02)	1.744(+01)	66344.3238	1.728(−03)	7.842(−33)	22	20	P	147	37
2105.8097	1.277(−02)	1.877(+01)	67810.1872	1.846(−03)	4.403(−33)	22	20	P	146	27
2106.8209	1.194(−02)	1.756(+01)	68742.5046	1.762(−03)	2.777(−33)	21	19	P	149	26
2108.3627	1.161(−02)	1.712(+01)	65820.4310	1.692(−03)	9.711(−33)	22	20	P	147	46
2110.2765	1.328(−02)	1.964(+01)	68459.4130	1.911(−03)	3.454(−33)	22	20	P	145	26
2110.3771	1.140(−02)	1.686(+01)	65389.3879	1.662(−03)	1.158(−32)	22	20	P	147	38
2110.8114	1.235(−02)	1.828(+01)	67035.8856	1.789(−03)	6.042(−33)	22	20	P	146	36
2111.7213	1.229(−02)	1.820(+01)	66884.7001	1.781(−03)	6.436(−33)	22	20	P	146	28
2114.5665	1.145(−02)	1.703(+01)	67690.8352	1.696(−03)	4.292(−33)	21	19	P	149	27
2116.6944	1.181(−02)	1.763(+01)	65978.0802	1.717(−03)	9.316(−33)	22	20	P	146	37
2117.4682	1.271(−02)	1.899(+01)	67433.9195	1.834(−03)	5.257(−33)	22	20	P	145	27

NOTES.—See text for explanation of columns. Table 14 is published in its entirety in computer-readable form in the AAS CD-ROM Series, Vol. 3.

TABLE 15

BEGINNING LINE LIST OF THE SECOND OVERTONE TRANSITIONS

σ	R^2	A	$E(v'' J'')$	gf	S	v'	v''	type	J''	isotope
cm^{-1}	D^2	Hz	cm^{-1}		cm/molecule					
3248.3425	7.262(−04)	3.916(+00)	69999.5215	1.652(−04)	1.770(−34)	23	20	P	149	26
3259.3392	6.902(−04)	3.760(+00)	68948.3033	1.576(−04)	2.707(−34)	23	20	P	149	27
3265.9575	7.233(−04)	3.965(+00)	69612.2062	1.644(−04)	2.124(−34)	23	20	P	148	26
3266.4789	6.662(−04)	3.653(+00)	68159.3991	1.524(−04)	3.733(−34)	23	20	P	149	36
3267.7667	6.611(−04)	3.629(+00)	68005.3522	1.513(−04)	3.971(−34)	23	20	P	149	28
3274.7213	6.312(−04)	3.487(+00)	67081.4706	1.448(−04)	5.750(−34)	23	20	P	149	37
3276.3294	6.876(−04)	3.805(+00)	68567.4004	1.567(−04)	3.240(−34)	23	20	P	148	27
3278.1390	6.146(−04)	3.406(+00)	66550.9300	1.411(−04)	7.109(−34)	23	20	P	149	46
3280.6441	6.012(−04)	3.340(+00)	66114.3966	1.382(−04)	8.461(−34)	23	20	P	149	38
3283.0112	6.634(−04)	3.694(+00)	67783.3560	1.515(−04)	4.453(−34)	23	20	P	148	36
3283.4737	7.205(−04)	4.013(+00)	69226.4014	1.635(−04)	2.548(−34)	23	20	P	147	26
3284.2108	6.583(−04)	3.669(+00)	67630.2615	1.504(−04)	4.735(−34)	23	20	P	148	28
3290.6434	6.287(−04)	3.525(+00)	66712.1271	1.439(−04)	6.838(−34)	23	20	P	148	37
3293.2248	6.850(−04)	3.850(+00)	68188.0212	1.559(−04)	3.873(−34)	23	20	P	147	27
3293.7669	6.123(−04)	3.442(+00)	66184.9088	1.403(−04)	8.440(−34)	23	20	P	148	46
3296.0330	5.990(−04)	3.375(+00)	65751.1194	1.374(−04)	1.003(−33)	23	20	P	148	38
3299.4520	6.607(−04)	3.734(+00)	67408.8446	1.507(−04)	5.309(−34)	23	20	P	147	36
3300.5640	6.557(−04)	3.709(+00)	67256.7040	1.496(−04)	5.643(−34)	23	20	P	147	28
3300.8911	7.177(−04)	4.062(+00)	68842.1295	1.626(−04)	3.054(−34)	23	20	P	146	26
3306.4779	6.263(−04)	3.562(+00)	66344.3238	1.431(−04)	8.126(−34)	23	20	P	147	37
3309.3092	6.100(−04)	3.478(+00)	65820.4310	1.395(−04)	1.001(−33)	23	20	P	147	46
3310.0259	6.825(−04)	3.895(+00)	67810.1872	1.551(−04)	4.628(−34)	23	20	P	146	27
3311.3379	5.968(−04)	3.409(+00)	65389.3879	1.366(−04)	1.189(−33)	23	20	P	147	38
3315.8014	6.581(−04)	3.775(+00)	67035.8856	1.498(−04)	6.325(−34)	23	20	P	146	36
3316.8263	6.531(−04)	3.750(+00)	66884.7001	1.487(−04)	6.719(−34)	23	20	P	146	28
3318.2101	7.150(−04)	4.111(+00)	68459.4130	1.617(−04)	3.657(−34)	23	20	P	145	26
3318.6950	6.204(−04)	3.568(+00)	68742.5046	1.442(−04)	2.848(−34)	22	19	P	149	26
3322.2250	6.239(−04)	3.600(+00)	65978.0802	1.423(−04)	9.648(−34)	23	20	P	146	37
3324.7660	6.078(−04)	3.515(+00)	65457.5155	1.387(−04)	1.187(−33)	23	20	P	146	46
3326.5588	5.947(−04)	3.444(+00)	65029.2202	1.358(−04)	1.407(−33)	23	20	P	146	38

NOTES.—See text for explanation of columns. Table 15 is published in its entirety in computer-readable form in the AAS CD-ROM Series, Vol. 3.

line list containing 2562 lines is also available for the pure rotational transitions. The first 30 transitions of these lengthy tables are given in Tables 12, 13, 14, and 15. The columns are identical to the columns in Tables 9, 10, and 11, except for the addition of a column at the extreme right which gives the isotopic designation, e.g., 26 for $^{12}C^{16}O$.

Tables 12–15 are available in their entirety in computer-readable form in the AAS CD-ROM Series, Vol. 3. They are also available as four text files using anonymous ftp over theinternet. Send e-mail to co@cma.arc.nasa.gov or co@128.102.20.45 with "CO linelist" in the body of the message. Instructions on retrieving the CO line lists will be returned.

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