A review of frequency measurements of optically pumped lasers from 0.1 to 8 THz

M. Inguscio and G. Moruzzi
Dipartimento di Fisica dell'Università di Pisa and Gruppo Nazionale di Struttura della Materia del CNR, I-56100 Pisa, Italy

K. M. Evenson and D. A. Jennings
National Bureau of Standards, Time and Frequency Division, Boulder, Colorado 80303

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We present a list of more than 800 far-infrared laser lines emitted by optically pumped molecular lasers whose frequencies have been measured. For each line, frequency, wavelength, wave number, lasing molecule, CO_2 pump line, and, if available, the assignment of the lasing transition, are given. The list is accompanied by a survey of the techniques of frequency measurement in the far infrared. Accuracies and limitations of the various techniques are also discussed.

INTRODUCTION

The first successful far-infrared (FIR) laser emission by an optically pumped molecular laser was reported by Chang and Bridges in 1970.[1] In an optically pumped FIR molecular laser, vibrational transitions of molecules displaying a permanent electric dipole moment are excited by a pump laser (usually CO_2). Population inversion is thus obtained in some of the rotational levels of the excited vibrational state. This extremely simple laser cycle, the richness of rovibrational spectra, and the large number of candidates as possible laser-active molecules have led to over a thousand FIR laser emissions in the spectral region between 35 μm and 2.9 mm. Before the introduction of optically pumped lasers, only a few lines emitted by discharge lasers were available in the FIR region. The short life of the recent FIR laser line catalogs[2–7] is good evidence for the steady growth of the number of laser emissions discovered.

Moreover, since this spectral region almost completely lacks alternative sources of coherent radiation, far-infared molecular lasers have found wide applications in several fields of physics. A few examples are atomic and molecular spectroscopy, where laser magnetic resonance is playing an important role[8]; astrophysics, where FIR molecular lasers have been used as local oscillators for heterodyne detection of atomic and molecular species in interstellar space[9]; and metrology, where the FIR radiation in the THz region has been used in frequency synthesis connecting the microwave region to the visible.[10,11] It was by fortuitous accident that one could find two nearly harmonically related lines, one from HCN at 337 μm and one about 12 times higher from H_2O at 28 μm, for extending frequency measurements between lasers in the first frequency-synthesis chain leading to the frequency measurement of methane[12] at 3.39 μm. The discovery of optically pumped molecular lasers provided hundreds of new frequencies and allowed a much simpler chain using only one FIR laser operating at 70 μm.[13]

The study of FIR laser emission from optically pumped molecular lasers also plays a very important role in the spectroscopy of the laser active molecule itself. These applications are possible because of the very good frequency reproducibility and stability obtained from optically pumped lasers. During the last few years several laboratories interested in the spectroscopic and metrological applications of these radiation sources have undertaken systematic frequency measurements.

The purpose of the present work is to provide a survey of the techniques of frequency measurements in the FIR region, with a discussion of accuracies and limits, and a current list of the FIR laser emissions whose frequencies have been measured.

CHARACTERISTICS OF THE FIR LASER LINES

The lasing transition occurs between two molecular levels yielding a gain profile which is inhomogeneously broadened by the Doppler effect. Typical Doppler widths range from 1 to 10 MHz, depending upon the particular frequency and molecular weight. Collisions and saturation result in a homogeneous broadening of

$$\gamma_{\text{hom}} = \gamma_{\text{coll}} \surd (I + I/I_s), \qquad (1)$$

where I is the laser intensity and I_s is the saturation intensity, and γ_{coll} is the collisional broadening. The shape of the FIR gain curve is also affected by the relative position of the pump frequency with respect to the center of the Doppler-broadened vibrational transition. In fact, the levels involved in the optical pumping cycle constitute a three-level system coupled by the IR and FIR laser radiations. A potential problem is the possible FIR frequency shifts and splittings originating in the IR pump transition.[14] The collisional broadening γ_{coll} is relatively high (10 – 40 MHz/Torr) for the polar molecules which constitute the active medium.

At typical pressures of continuous wave lasing (5–500 mTorr), γ_{hom} is of the order of a few megahertz. It is nearly independent of pressure because the saturation intensity I_s decreases with pressure, and the collisional broadening increases. The wide gain profile makes it possible to tune the FIR laser emission over a range of a few tens of megahertz by sweeping the cavity length, the actual tunability depending on the particular transition and on threshold conditions.

On the other hand, very narrow linewidths, on the order of or less than 1 kHz, can be obtained due to the absence of a plasma in the cavity with its inherent fluctuations in the index of refraction. It has been possible to obtain fractional frequency instabilities as low as 2×10^{-12} by phase-locking techniques in an apparatus especially designed for metrological purposes.[15]

For a transversally pumped, open structure resonator, the uncertainty in the frequency reproducibility is determined mainly by the accuracy in the determination of the maximum (center) of the gain curve. For a transversely pumped open-structure resonator the frequency reproducibility is of the order of two parts in 10^7. Frequency measurements on these lasers are therefore less accurate than in the case of saturation stabilized (sub-Doppler) gas lasers; nevertheless, their accuracy is much higher than that of wavelength measurements. These frequency measured FIR lines are therefore of considerable value for FIR spectroscopy.

DIRECT FREQUENCY MEASUREMENTS

Conceptually, the simplest scheme for measuring a laser frequency ν_L is by beating the laser radiation directly with a harmonic of the radiation of a microwave oscillator of known frequency ν_M in a harmonic generator mixer such as a Josephson junction, a Schottky diode, or a metal-insulator-metal (MIM) diode. The value of ν_L can thus be evaluated from the beat frequency $\delta\nu$, and its sign and the harmonic order n by means of the equation

$$\nu_L = n\nu_M + \delta\nu. \qquad (2)$$

Both n and the sign of $\delta\nu$ can be established by varying ν_M, and for this purpose a wide band spectrum analyzer of the order of 1 GHz is useful.

The microwave oscillator (usually a klystron oscillating at less than 100 GHz) can be phase-locked to a quartz-crystal-controlled oscillator typically at 100 MHz or lower. In the multiplication process the phase noise of the crystal oscillator is also multiplied to the laser frequency broadening the carrier.[16] If the multiplication is too large, the carrier can totally disappear. Using the best available crystal oscillators, direct frequency multiplication to a few terahertz is theoretically possible.[16]

In the original work by Chang and Bridges[1] the FIR laser emission was heterodyned with the higher harmonics of a tunable microwave source in a point contact diode. The accuracy of this method, ± 3 MHz for frequencies of the order of 600 GHz, was limited mainly by the free running instability of the microwave oscillator. This first work on an optically pumped FIR molecular laser also provided clear evidence for the significant contributions that precise frequency measurements of the laser emission could make to the spectroscopy of the lasing molecule itself. FIR laser transitions typically occur between high J levels, which involve centrifugal distortions and other perturbative effects not observable at the low J values typical of the microwave transitions. In particular, Chang and Bridges were able to significantly improve the accuracy of the rotational constant B_1 and of the centrifugal distortion constants D_{J1} and D_{JK1} for the first excited ν_3 state of CH_3F.

Locking the microwave oscillators to quartz oscillators significantly reduces the linewidth of the reference source, so that the experimental error in determining the laser frequency is due only to the determination of the maximum of the laser emission profile.

The most common microwave sources are klystrons, operating either in X or K band, and several klystrons are required in order to cover the FIR region continuously. However, the most severe limitation to the technique of Eq. (2) is the highest harmonic which can be generated in the harmonic generator mixer.

The Schottky barrier diode constitutes a very good high harmonic generator at room temperature; its responsivity, however, decreases dramatically above 1 or 2 THz. The highest harmonic ($n = 33$) was obtained in measuring the 2.5-THz frequency of the very strong CH_3OH laser emission at 119 μm.[17] The highest frequency in harmonic generation in a Schottky barrier diode was 5.3 THz,[18] which, however, was obtained using only the 13th harmonic of a 408-GHz oscillator.

Faster detectors, like point contact MIM diodes, on the other hand, are limited to about the 20th harmonic, thus their measuring range from microwave sources does not reach frequencies much higher than 1 THz.[19]

Josephson junctions easily generate high-order harmonics, allowing good measurements up to about 2 THz. They become much less sensitive at 4 THz, probably because the photon energy becomes high enough to split the paired electrons required for superconductivity. The CH_3OH laser line at 70 μm (4.25 THz) was phase locked to a 99 GHz by 43rd harmonic mixing in a Josephson junction.[13] Higher-order harmonic generation (up to the 100th order) has been used to measure frequencies up to 2.06 THz.[20]

Thus, although the procedure described by Eq. (2) is extremely convenient because the unknown laser frequency can be directly connected to an easily measurable microwave frequency referenced to an excellent frequency standard, there are important limitations at high frequencies mainly due to the fact that the harmonic order must increase with the laser frequency.

The need to use very high harmonic orders can be eliminated by using two stabilized CO_2 lasers to synthesize a FIR frequency. This technique has been introduced at the NBS Laboratories in Boulder[21,22] and is schematically illustrated in Fig. 1. A point contact W-Ni MIM diode is used as a harmonic generator mixer, so that we have three-laser mixing, with the unknown FIR laser frequency ν_L obtained by

$$\nu_L = n_1\nu_{L1} - n_2\nu_{L2} \pm m\nu_M \pm \delta\nu, \qquad (3)$$

where ν_{L1} and ν_{L2} are the frequencies of the two CO_2 lasers operating in the 9.4- or 10.4-μm bands, ν_M is a microwave frequency (X band or less), and $\delta\nu$ is the beat frequency measured by a spectrum analyzer. n_1, n_2, and m are small positive or negative integers such that the mixing order is less than about 10. The several hundred CO_2 frequencies available from eight isotopic species cover the spectrum from 25 to 30 THz (9 to 11 μm). Each line can be stabilized to a narrow saturated absorption feature very close to the true molecular frequency. These frequencies are easily reproducible to within one part in 10^{12}.[23,24] Over 7000 difference frequencies in the region between 0.025 and 5.8 THz can thus be produced with an uncertainty of about 35 kHz for most

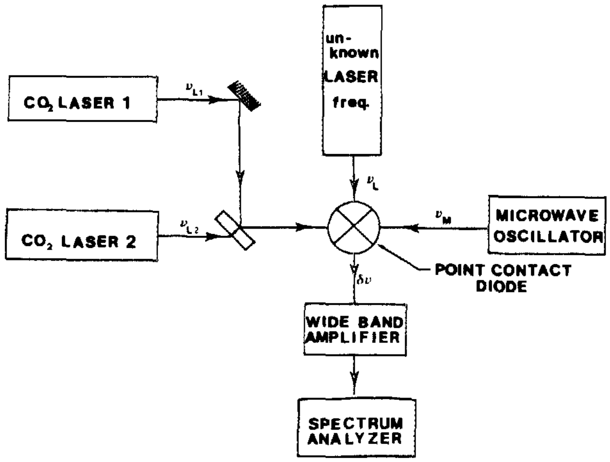

FIG. 1. Schematic diagram of the two CO_2 laser frequency synthesis experiment at the National Bureau of Standards, Boulder, CO. The frequencies of the two CO_2 lasers ν_{L1} and ν_{L2}, the frequency ν_M of the microwave oscillator, and the unknown laser frequency ν_L are fed into a point contact MIM diode used as a harmonic generator mixer, and the beat frequency $\delta\nu$ is measured by means of a spectrum analyzer. The unknown laser frequency is obtained from Eq. (3).

pairs using the 85 lines from just one isotope of CO_2. In most cases this scheme can be used to synthesize a frequency to within 10 GHz of ν_L. Since the bandpass of the frequency measurement system is only about 1500 MHz it is usually necessary to reduce $\delta\nu$ by adding a frequency ν_M from an X-band klystron. The X-band klystron can be stabilized to a quartz-crystal-controlled oscillator, resulting in an uncertainty of less than 100 kHz for the synthesized frequency. The beat signal is amplified (25 dB) and measured on a spectrum analyzer. This experimental technique has been used to measure most of the FIR laser lines. Almost all of the frequencies higher than 3 THz have been measured by this technique.

Because of the limited bandpass of the frequency measurement system, a wavelength uncertainty of at least about one part in 10^4 is required (e.g., 1500 MHz at 40 μm implies $\Delta\lambda/\lambda = 2\times10^{-4}$). This was achieved by using a single-mode FIR resonator and calibrating the cavity length scan by comparison to known wavelengths.

With essentially the same scheme the MIM point contact diode has been used to detect a FIR difference frequency $\nu_{L1} - \nu_{L2}$, *and* to generate FIR radiation.[25] Furthermore, the use of a tunable (high-pressure) CO_2 laser provides several hundred megahertz of tunable FIR radiation on each CO_2 line.

Precise frequency measurements made using the above methods are now available for more than 800 FIR laser lines. This makes a new, simpler technique possible. The idea of this technique, which was first used by Tittel[26] and is now used in Pisa,[66] is to heterodyne the investigated emission, for which a wavelength measurement only is available, with another FIR laser line whose frequency has already been measured by means of one of the preceding methods. If needed, microwave radiation can also be mixed in the diode. The limit to the accuracy of this method is set by the uncertainty in tuning both optically pumped FIR lasers to the centers of their emission profiles.

The accuracy is thus just a factor $\sqrt{3}$ larger than that of the other methods. On the other hand, the limit to the applicability of this technique is set by the availability of a frequency measured laser line in the neighborhood of the investigated line. This availability is, of course, becoming better with every new frequency measurement. Thus it was almost accidental, when Tittel's measurement was made, that HCN oscillated at a frequency close to the investigated HCOOH line at 311 μm. The situation is by far better now. Figure 2 displays the density of available lines with measured frequencies as a function of frequency, thus indicating the probability of being able to use this technique for frequency measurement.

The accidental redetermination of 20 or 30 lines from mixed isotopes at the National Bureau of Standards has indicated a fractional uncertainty in the frequency measurements of the FIR lines of about $\pm 2\times10^{-7}$. This uncertain-

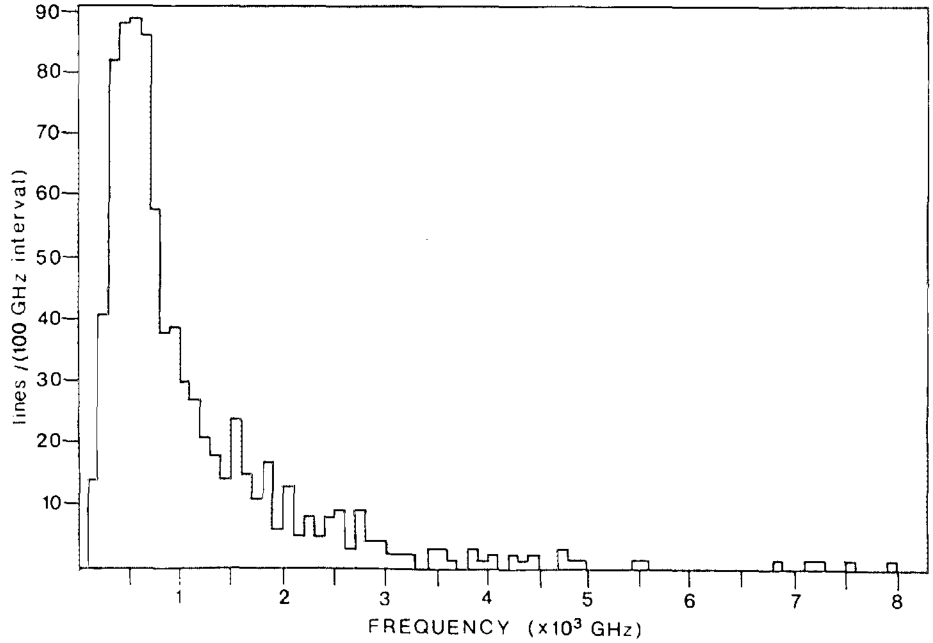

FIG 2. Available frequency measured laser lines in the FIR spectral region. The ordinate reports the number of lines for each 100 GHz interval.

ty is due almost entirely to the resettability of the transversally pumped open structure resonator used. Longitudinally pumped resonators exhibit pump pulling effects which increase the fractional uncertainty to about $\pm 5\times 10^{-7}$.

THE TABLES

Table I reports all the measured frequencies we have located either in the literature or from private communications. Column 1 gives a number for the line; column 2 gives the frequency in GHz; and column 3 reports the lasing molecule (any isotope different from the naturally most abundant one is specified by its mass number in the molecular formula). Column 4 reports the assignment of the laser transition, when available and column 5 gives the CO_2 pump line. Columns 6 and 7 report comments and references. The most frequent comments refer to the fact that a line has been independently measured in different laboratories. In this case Table I reports only one frequency value, either an average or the measurement which seems to be the most reliable (all of the independent measurements with their respective experimental accuracies are reported in the footnotes to Table I).

In Table II, columns 1 and 2 give again the line number and the frequency in GHz; columns 3 and 4 report the wave numbers and the wavelengths, in cm^{-1} and μm. The CO_2 pump line is given in column 5 and the lasing molecule in column 6.

At the end of each appropriate reference we list the molecules investigated and the experimental accuracies.

TABLE I. Frequencies, lasing molecules, assignments, and CO_2 pumps of the FIR laser lines.

No.	Frequency (GHz)	Molecule	Transition	CO_2 pump	Comment	References
1	144.8141	CH_2F_2		10P(14)		28
2	147.5879	$(H_2CO)_3$	$\nu_5\ (J,K):[14,5(4)]-[13,5(4)]$	10R(30)		29
3	150.5922	$CD_3\,^{37}Cl$	$\nu_5\ (J,K):(1,7,0)-(1,6,0)$	9P(14)		30,31
4	152.5155	$CH_3\,^{79}Br$	$\nu_6\ (J,K):(8,1)-(7,1)$	10P(28)		32,33
5	157.7947	C_2H_3Br		10P(20)		34
6	158.8981	CH_3Cl		9P(26)		79
7	164.0159	ClO_2		10P(20)		5
8	173.2070	HCOOD		10R(24)		35,36
9	174.8948	CD_2F_2		9P(30)		37
10	185.6429	C_2H_3Br		10P(26)		34
11	189.5375	$(H_2CO)_3$		9P(26)		29
12	189.7537	$(H_2CO)_3$	$\nu_5\ (J,K):(18,13)-(17,13)$	10R(12)		29
13	193.4763	CD_3I	$\nu_5\ (J,K):(16,5)-(15,5)$	9R(10)		31,38
14	194.4494	HCOOD		9P(30)		35,36
15	197.0535	C_2H_5F		9P(10)		5
16	200.9539	$H^{13}COOH$	$\nu_6\ (J,K_a,K_c):[9,8,2(1)]-[8,8,1(0)]$	9P(14)		27,35
17	207.0253	CH_2F_2		9R(44)		39,40
18	215.0495	C_2H_3Br		10R(20)		34
19	216.6315	C_2H_3Br		10P(24)		34
20	228.7186	ClO_2		10P(14)		5
21	228.7498	$CH_3\,^{79}Br$		10R(4)		5
22	231.9041	$(H_2CO)_3$	$\nu_5\ (J,K):(22,14)-(21,14)$	10R(10)		29
23	233.9116	DCOOD		9P(38)		35,36
24	237.8247	CDF_3	$qR(11,4)+1$	10R(16)		41
25	239.0958	CH_3I	$\nu_6\ (J,K,F):(16,6,33/2)-(15,6,31/2)$	10P(32)		5,42
26	239.1028	CH_3I	$\nu_6\ (J,K,F):(16,6,29/2)-(15,6,27/2)$	10P(32)		28,38,42,43,44
27	239.1042	CH_3I	$\nu_6\ (J,K,F):(16,6,35/2)-(15,6,33/2)$	10P(32)		5,42
28	239.1192	CH_3I	$\nu_6\ (J,K,F):(16,6,27/2)-(15,6,25/2)$	10P(32)	g	28,38,42,43
29	240.2965	C_2H_3Br		10R(12)		34
30	241.8696	$CD_3\,^{35}Cl$	$\nu_5\ (J,K):(11,2)-(10,2)$	9P(12)		30,31
31	242.1654	DCOOH		10R(24)		35,36
32	244.9966	CH_3OH	$(n,\tau,K;J):(0,1,0;11)-(0,3,1+;10)$	9P(16)		45,46
33	245.3507	$^{13}CH_3F$		9P(32)		41
34	245.3508	$^{13}CH_2F_2$		9P(32)	i	47,48
35	247.0758	$H^{12}COOH$	$\nu_8\ (J,K_a,K_c):(11,4,8)-(10,4,7)$	9P(28)		35,36
36	252.9726	$(H_2CO)_3$	$\nu_5\ (J,K):(24,13)-(23,13)$	10R(22)		29
37	258.0688	HCOOD		10R(20)		35,36
38	259.0407	HCOOD		10R(38)		35,36
39	264.3409	ClO_2		10P(16)		5
40	265.8319	C_2H_3CN		10P(26)		28
41	268.5148	$H^{13}COOH$	$\nu_6\ (J,K_a,K_c):(12,3,10)-(11,3,9)$	9R(30)		27,35
42	272.6516	CD_3I		10P(22)		28,31,38
43	274.6260	CH_2F_2		9P(16)	c	79
44	277.4476	CDF_3	cascade $qR(13,10)-1$	10R(12)		41
45	280.1195	DCOOD		9P(12)		35,36
46	283.6654	CH_3Br		10P(18)		28

TABLE I. Continued.

No.	Frequency (GHz)	Molecule	Transition	CO_2 pump	Comment	References
47	284.5744	$(H_2CO)_3$	$\nu_5\ (J,K)$: (27,14)–(26,14)	10R(22)		29
48	286.1766	DCOOH		10R(12)		35,36
49	288.3021	C_2H_3Cl		9P(24)		28
50	290.9538	$H^{13}COOH$	$\nu_6\ (J,K_a,K_c)$: (13,3,11)–(12,3,10)	9R(30)		27,35
51	291.9936	C_2H_3Cl		10R(28)		28
52	292.0018	C_2H_3Cl		10R(38)		28
53	294.4169	CH_2F_2	$\nu_9\ (J,K_a,K_c)$: [20,8(7),13]–[19,8(7),12]	10P(14)		28,42
54	295.0688	C_2H_3CN		10P(32)		28
55	296.9979	DCOOD		10R(18)		35,36
56	297.2486	CDF_3	$qR(14,10) - 1$	10R(12)		41
57	298.1978	CD_3I	$\nu_2 + \nu_3\ (J,K)$: (26,10)–(25,10)	10P(34)		28,38
58	300.2386	DCOOD		9P(12)		35,36
59	302.6280	C_2H_3Br		10R(4)		34
60	302.6466	$CH_3{}^{81}Br$		10P(10)		28,33
61	303.0685	C_2H_3Br		10P(16)		34
62	303.2203	C_2H_3Cl		10R(28)		28
63	303.3540	C_2H_3Cl		10P(24)		28
64	303.9415	C_2H_3CN		10P(28)		28
65	303.9528	HCOOD		10R(32)		35,36
66	304.0275	CHD_2F		10R(20)		2
67	304.0927	C_2H_3Br		10R(2)		34
68	304.4211	CHD_2F		10P(46)		49
69	305.3780	CD_3I		10P(22)		28,38
70	308.4899	DCOOH		10R(28)		35,36
71	311.1535	C_2H_3Br		10P(10)		34
72	314.0943	CH_2F_2	$\nu_4\ (J,K_a,K_c)$: (45,16,29)–(45,16(15),30)	10P(30)		28
73	314.2874	CD_3I	$\nu_5\ (J,K)$: (25,3)–(24,3)	9R(28)		31,38
74	315.6757	ClO_2		10P(16)		5
75	315.9286	$(H_2CO)_3$		9R(24)		29,50
76	316.1534	$(H_2CO)_3$	$\nu_5\ (J,K)$: [30,9(10)]–[29,9(10)]	10R(6)		29
77	317.5675	CH_3Cl		9R(12)		79
78	317.5703	CH_3Cl		9R(12)		79
79	318.4246	CD_3Br		10R(18)		28,51
80	320.0851	DCOOD		10P(26)		35,36
81	320.2367	C_2H_3Br		10R(32)		34
82	320.4268	$^{13}CH_2F_2$		9R(10)		47,48
83	320.6304	DCOOD		9P(16)		35,36
84	320.9003	C_2H_3Br		9P(28)		34
85	323.0587	DCOOD		10P(20)		35,36
86	323.6770	HCOOD	$\nu_5\ (J,K_a,K_c)$: (15,9,6)–(14,9,5)	10R(14)		35,36,42
87	325.8842	HCOOD		10R(32)		35,36
88	326.3544	CD_3I	$\nu_5\ (J,K)$: (26,3)–(25,3)	9R(28)		31,38
89	326.5187	CH_2F_2	$\nu_9\ (J,K_a,K_c)$: (22,9(8),14]–[21,9(8),13]	10P(22)		28,42
90	326.6138	CH_2F_2	$\nu_9\ (J,K_a,K_c)$: [21,10(9),12]–[20,10(9),11]	10P(22)		28,42
91	327.7208	ClO_2		9R(14)		5
92	327.7297	ClO_2		9R(14)		5
93	327.7368	ClO_2		9R(14)		5
94	331.1058	$CHCl_2F$		9R(4)		52
95	332.0738	$^{13}CH_2F_2$		9R(30)		47,48
96	332.6626	C_2H_3CN		10R(12)		28
97	333.0532	C_2H_3Br		10R(18)		34
98	333.3309	CF_2HCl		9R(38)		53
99	334.0229	$^{13}CH_2F_2$		9P(14)		47,48
100	335.3303	$^{13}CH_2F_2$		9R(16)		47,48
101	336.4344	$H^{13}COOH$	$\nu_8\ (J,K_a)$: (15,5)–(14,5) (tentative)	10R(32)		27,35
102	336.9529	$(H_2CO)_3$		9R(26)		29
103	337.0478	$(H_2CO)_3$		9R(20)		29
104	337.1919	CH_2F_2	$\nu_9\ (J,K_a,K_c)$: [23,9(8),15]–[22,9(8),14]	10P(22)		28,42
105	337.2767	CH_2F_2	$\nu_9\ (J,K_a,K_c)$: [22,10(9),13]–[21,10(9),12]	10P(22)		28,42
106	339.2860	CD_3Cl		9P(34)		28,30
107	341.6251	DCOOD		10P(26)		35,36
108	343.9624	CD_3OH		9R(14)		54
109	347.5680	CHD_2F		10R(20)		49
110	349.3051	CD_3OH		10R(18)		54
111	350.8048	CH_3CN	$\nu_7 + \nu_8, A\ (J,K)$: (19,3)–(18,3)	9P(16)		55
112	351.2762	C_2H_3Br		10P(10)		34
113	352.1484	CD_3Br		10R(18)		28,51
114	355.5258	DCOOD		9P(12)		35,36
115	355.7847	CH_2F_2	$\nu_4\ (J,K_a,K_c)$: (15,4,1)–(14,2,2)	10P(30)		28

TABLE I. Continued.

No.	Frequency (GHz)	Molecule	Transition	CO_2 pump	Comment	References
116	355.9952	CF_2HCl		9R(16)		53
117	357.5897	$H^{13}COOH$	$\nu_6\ (J,K_a,K_c) : [16,6,11(10)]–[15,6,10(9)]$	9P(12)		27,35
118	359.9999	$CHCl_2F$		9R(4)		52
119	360.6451	$CH_3\ {}^{81}Br$	$\nu_6\ (J,K) : (19,0)–(18,0)$	10P(28)		32,33
120	362.5304	C_2H_3Br		10P(22)		34
121	367.3051	C_2H_3CN		10P(16)		28
122	367.7880	C_2H_3Cl		9P(24)		28
123	368.4053	HCOOD		9P(12)		35,36
124	368.4522	$(H_2CO)_3$		9P(32)		29
125	379.5612	$H^{12}COOH$		9R(36)		35,36
126	379.7628	DCOOD		10R(20)		35,36
127	380.0040	$H^{13}COOH$	$\nu_6\ (J,K_a,K_c) : [17,6,12(11)]–[16,6,11(10)]$	9P(12)		27,35
128	380.2149	CD_3I	$\nu_2 + \nu_3\ (J,K) : (30,?)–(29,?)$	10P(12)		28,38
129	380.9588	$H^{12}COOH$		9R(32)		35,36
130	381.3369	$H^{12}COOH$	$\nu_6\ (J,K_a,K_c) : (17,3,15)–(16,3,14)$	9R(40)		35,36,56
131	382.2576	C_2H_3Br		10P(24)		34
132	384.2838	C_2H_3Br		10P(14)		34
133	384.4112	DCOOD		10P(26)		35,36
134	388.8169	$(H_2CO)_3$		10P(20)		29
135	389.8201	C_2H_3CN		10R(44)		28
136	390.3488	CHD_2F		10R(26)		48
137	393.5515	DCOOD		10P(10)		35,36
138	398.2638	DCOOH		10R(34)		35,36
139	398.2966	CD_2O		9R(32)	g	28,50
140	398.7497	C_2H_3CN		10P(28)		28
141	399.4006	$(H_2CO)_3$		10P(20)		29
142	400.0487	$CH_3\ {}^{79}Br$	$\nu_6\ (J,K) : (21,3) : (20,3)$	10R(14)		32,33
143	400.0584	$(H_2CO)_3$		9P(30)		29
144	400.0587	$CH_3\ {}^{79}Br$	$\nu_6\ (J,K) : (21,0)–(20,0)$	10P(14)		32,33
145	400.0603	CH_3Br		10R(14)		28
146	401.3017	CF_2HCl		9R(10)		53
147	402.9196	$H^{12}COOH$	$\nu_6\ (J,K_a,K_c) : [18,8,11(10)]–[17,8,10(9)]$	9R(24)	g	35,36,56,57,58
148	403.7217	$H^{12}COOH$	$\nu_6\ (J,K_a,K_c) : (18,3,16)–(17,3,15)$	9R(40)	g	35,36,56,57,58
149	404.5155	C_2H_3Br		10P(20)		34
150	405.9951	$^{13}CH_2F_2$		9R(12)		47,48
151	406.7117	CD_2O		10R(32)		28
152	407.4264	CH_3Br		10R(12)		5
153	407.8089	$CD_3\ {}^{37}Cl$	$\nu_5\ (J,K) : (19,0)–(18,0)$	9P(6)		28
154	407.9038	$^{13}CH_2F_2$		9P(36)		47,48
155	408.2906	CD_3I	$\nu_3 + \nu_5\ (J,K) : (33,0)–(32,0)$	9P(22)		28,38
156	408.3467	N_2H_4		10R(38)		5
157	408.6611	CD_2O	$\nu_6\ (J,K-,K+) : (7,4,4)–(6,4,3)$	9P(32)		59
158	408.6738	CD_2O		9P(32)	g	28,50
159	410.4927	CD_3I	$\nu_5\ (J,K) : (35,7)–(34,7)$	9R(28)		31,38
160	411.8316	HCOOD		10R(42)		35,36
161	412.0463	C_2H_3CN		10P(16)		28
162	412.4145	DCOOD		10P(10)		35,36
163	413.5523	CH_2F_2	$\nu_9\ (J,K_p,K_0) : (35,6,30)–(35,5,31)$	9P(4)		39,40
164	413.9980	C_2H_3Br		10P(14)		34
165	415.0184	$^{18}O_3$		9P(10)		60
166	419.0617	$CH_3\ {}^{79}Br$	$\nu_6\ (J, K) : (22,3)–(21,3)$	10R(14)		32,33
167	420.4040	DCOOH		10R(34)		35,36
168	421.2037	$(H_2CO)_3$		9R(32)		29
169	423.9021	C_2H_3Br		10R(24)		34
170	425.2827	C_2H_3Cl		9P(18)		28
171	428.6285	CH_3OH	$(n,\tau,K;J) : (1,2,5;9)–(1,2,5;8)$	9P(34)	a,g	28,44,45,46,61,62
172	429.1607	$CD_3\ {}^{37}Cl$	$\nu_5\ (J,K) : (20,1)–(19,0)$	9P(6)		28,30
173	429.8376	DCOOH		10R(36)		35,36
174	430.9394	HCOOD		10R(36)		35,36
175	431.1390	CH_3OH		10R(16)		45,46
176	431.2307	C_2H_3Cl		9P(22)		28
177	431.7114	$(H_2CO)_3$		9R(16)		29
178	431.8598	CH_3OH		9P(24)		45,46
179	432.5138	C_2H_3Br		10R(16)		34
180	433.2106	$CD_3\ {}^{79}Br$	$\nu_5\ (J,K) : (28,2)–(27,2)$	9P(26)		28,51
181	433.6958	CHD_2F		10R(26)		49
182	433.7782	CD_3I	$\nu_3 + \nu_5\ (J,K) : (35,5)–(34,5)$	9R(20)		28,38
183	434.4830	HCOOD		10R(26)		35,36
184	435.0000	$^{13}CH_2F_2$		9R(22)		47,48

TABLE I. Continued.

No.	Frequency (GHz)	Molecule	Transition	CO_2 pump	Comment	References
185	435.8481	CDF_3	cascade $qR(21,17) - 1$	10R(10)		41
186	438.4607	C_2H_3Cl		10R(20)		28
187	439.4656	CF_2HCl		10P(14)		53
188	440.5205	C_2H_3Br		10R(16)		34
189	441.0232	$(H_2CO)_3$		10P(34)		29
190	442.1967	CH_2F_2		9P(12)	c	79
191	444.7554	$^{13}CH_2F_2$		9P(4)		47,48
192	447.3751	CD_3I		10R(8)		28,38
193	447.3887	CD_3I		10R(8)		28,38
194	447.7650	$H^{12}COOH$		9R(30)	g	35,36,56,57,61
195	449.3075	CD_3I	$\nu_3 + \nu_5$ (J,K) : (38,10)–(37,10)	10P(10)		28,38
196	449.7310	C_2H_3Cl		10R(20)		28
197	450.2164	CF_2HCl		10P(18)		53
198	452.3015	CH_2F_2		10P(24)	g	28,61
199	453.4389	$CHCl_2F$		9R(30)		52
200	453.6246	$^{13}CH_3{}^{79}Br$		10R(20)		5
201	453.8306	CD_3I		10P(46)		28,38
202	455.5062	CDF_3	$qR(22,6) + 1$	10P(6)		41
203	455.6191	CDF_3	$qR(22,17) - 1$	10R(10)		41
204	455.6547	CDF_3	$qR(22,15) + 1$	10P(12)		41
205	456.1391	CH_2F_2		9P(10)		39,40
206	461.5862	C_2H_3Cl		9P(20)		28
207	461.6272	C_2H_3Br		10P(18)		34
208	463.1083	DCOOH		10R(30)		35,36
209	463.7324	CD_3OH		10R(8)		54
210	465.8664	CD_2F_2		9P(22)		37
211	466.5305	CH_2F_2		10R(44)		39,40
212	469.0647	DCOOH		10P(8)		35,36
213	469.6041	$^{13}CH_2F_2$		9P(26)		47,48
214	471.8505	C_2H_3Br		10R(26)		34
215	472.5077	C_2H_3Cl		9P(20)	g	28,61
216	474.3180	$CH_3{}^{79}Br$		10P(22)		28,33
217	475.7356	HCOOD		10R(10)		35,36
218	475.9787	$^{13}CH_3OH$		9P(12)		63
219	480.1057	CH_3OH	$(n,\tau,K;J)$: (0,2,5;10x)–(0,2,5;9x)	9P(38)		45,46
220	480.3629	C_2H_3Br		10R(18)		34
221	484.3987	$^{13}CH_2F_2$		9R(8)		47,48
222	484.7511	C_2H_3Br		10R(30)		34
223	485.3713	CF_2HCl		9P(28)		53
224	486.4115	CH_2DOH		9P(26)		64
225	487.2066	CF_2HCl		10R(14)		53
226	488.0347	CH_3OH		9P(24)	g	28,45,46
227	488.1740	CD_3I	(ν_3,J,K) : (2,42,4)–(2,41,4)	10R(22)		28,38
228	493.3118	$(H_2CO)_3$		10P(36)		29
229	497.5916	CH_3OH		9P(24)		45
230	498.0791	CH_2CHCl		10P(38)		61
231	500.0292	CD_3I	(ν_3,J,K) : (2,43,4)–(2,42,4)	10R(22)		38
232	504.0828	C_2H_3Br		10P(32)		34
233	505.1214	CH_3CH_2F		9P(36)		61
234	505.3141	CD_2F_2		9P(30)		37
235	505.7584	CH_2F_2		9R(16)		79
236	506.0294	CF_2HCl		9R(40)		53
237	506.7351	DCOOD		10R(26)		35,36
238	506.8851	CH_2F_2		10P(26)		28
239	507.1214	CH_2F_2		9P(14)	c	79
240	507.1511	CF_2HCl		10R(24)		53
241	507.8048	C_2H_3Cl		9P(18)		28
242	508.7082	CH_3CN		9P(30)		5
243	509.8272	CH_2F_2		9R(46)		39,40
244	509.9513	CH_2F_2		9P(16)	c	79
245	511.2581	C_2H_3CN		10P(20)		28
246	511.7858	$CH_3{}^{81}Br$	ν_6 (J,K) : (27,8)–(26,8)	9P(40)		32,33
247	513.4555	C_2H_3CN		10P(12)		28
248	514.6178	HCOOD		9P(18)		35,36
249	515.1211	CDF_3	$qR(25,21) + 1$	10R(28)		41
250	516.1102	$CHCl_2F$		9R(12)		52
251	516.1707	$H^{12}COOH$		9P(38)		35,36
252	516.5387	$H^{12}COOH$		9R(22)		35,56
253	517.0965	C_2H_3Cl		10P(16)		28

TABLE I. Continued.

No.	Frequency (GHz)	Molecule	Transition	CO_2 pump	Comment	References
254	522.2622	C_2H_3CN		10R(16)		28
255	523.4797	C_2H_3CN		10R(20)		28
256	523.8104	$H^{13}COOH$	ν_6 (J,K_a,K_c) : (24,2,23)–(23,2,22)	9R(32)		27,35
257	525.4275	CH_3OH	$(n,\tau,K;J)$: (0,1,0;11)–(0,1,0;10)	9P(16)	a,g	21,28,41,43,45,46,61
258	525.6453	$^{13}CH_2F_2$		9R(20)		47,48
259	526.4344	CD_3I	ν_2 (J,K) : (46,9)–(45,9)	10P(36)		28,38
260	527.8541	C_2H_3Cl		10P(16)	g	28,61
261	527.9260	DCOOD		10R(26)		35,36
262	528.2392	CH_2F_2		9R(28)		39,40
263	528.6352	HCOOD		10P(14)		35,36
264	533.0118	CF_2HCl		9R(34)		53
265	534.1096	DCOOD		10P(20)		35,36
266	534.3628	$CHCl_2F$		9R(40)		52
267	534.5774	CDF_3	$qR(26,10)+1$	10R(40)		41
268	534.6727	CDF_3	cascade $-qR(26,18)-1$	10R(36)		41
269	536.7073	$(H_2CO)_3$		9R(10)		29
270	538.3473	CD_3I	ν_2 (J,K) : (46,9)–(45,9)	10P(36)		28,38
271	538.4178	$CD_3{}^{81}Br$	ν_5 (J,K) : (35,2)–(34,2)	9R(30)		28,51
272	539.1013	CF_2HCl		9R(34)		53
273	540.7851	CH_2F_2	ν_9 (J,K_a,K_c) : [32,19(18),14]–[31,19(18),14]	10P(14)	g	28,61
274	541.2562	$CD_3{}^{79}Br$	ν_5 (J,K) : (35,3)–(34,3)	9P(32)		28,51
275	541.4385	C_2H_3Br		10P(40)		34
276	545.3882	C_2H_3CN		10P(14)		28
277	545.8132	$CHCl_2F$		9R(8)		52
278	546.2253	$H^{13}COOH$	ν_6 (J,K_a,K_c) : (26,1,26)–(25,1,25)	9P(20)		27,35
279	547.5376	$CHCl_2F$		9R(10)		52
280	549.6628	$CH_3{}^{81}Br$	ν_6 (J,K) : (29,7)–(28,7)	10R(32)		28,33
281	549.7960	$CH_3{}^{81}Br$	ν_6 (J,K) : (29,3)–(28,3)	10P(38)		28,32,33
282	554.1590	CH_2F_2		9R(42)		39,40
283	554.4156	CDF_3	$qR(27,18)-1$	10R(36)		41
284	559.2141	$H^{13}COOH$	ν_6 (J,K_a,K_c) : [25,7,19(18)]–[24,7,18(17)]	9P(24)		27,35
285	560.9570	CF_2HCl		9R(34)		28,53
286	561.7240	$H^{12}COOH$	ν_6 (J,K_a,K_c) : (25,5,21)–(24,5,20)	9R(28)		35,36
287	561.7475	$H^{12}COOH$		9P(16)	g	28,35,56
288	561.7720	N_2H_4		10R(8)		5
289	561.8586	CH_2F_2		9R(6)		79
290	562.3174	CF_2HCl		10R(16)		53
291	564.1953	$^{13}CH_2F_2$		9P(8)		47,48
292	564.2953	$^{13}CH_2F_2$		9P(8)		47,48
293	564.5407	$CH_3{}^{81}Br$		10R(18)		28,33
294	564.7361	$CHCl_2F$		9R(6)		52
295	565.0778	C_2H_3Cl		9P(16)		28
296	565.5051	$CD_3{}^{79}Br$	ν_2 (J,K) : (37,0)–(36,0)	10R(10)		28,51
297	565.7742	CD_3CN	$\nu_6+2\nu_8$ (J,K) : (36,11)–(35,11)	9R(4)		28,55
298	566.8436	CH_2F_2		9P(18)	c	79
299	567.2553	C_2H_3Br		10R(40)		28,34
300	567.9254	N_2H_4		9P(12)		61
301	568.6346	DCOOD		10P(34)		28,35
302	569.4219	DCOOD		10P(34)		28,35
303	572.7721	CD_3I	ν_2 (J,K) : (49,13)–(48,13)	10P(38)		28,38
304	573.1168	CH_2DOH		9P(40)		64,65
305	575.1561	CDF_3	ground-state refilling transition	10R(24)		41
306	577.2975	CD_3Cl		9P(36)		28,30
307	577.5511	CH_3CH_2F		9R(4)		61
308	580.7082	CD_3CN	ν_6 (J,K) : (37,1)–(36,1)	9P(30)		28,55
309	581.9297	$H^{12}COOH$	ν_6 (J,K_a,K_c) : (26,12,15)–(25,12,14)	9P(16)	g	28,35
310	582.1770	DCOOD		10P(34)		28,35
311	584.3729	$H^{12}COOH$		9R(28)		28,35
312	584.3882	$H^{12}COOH$	ν_6 (J,K_a,K_c) : (26,5,22)–(25,5,21)	9R(28)	g	35,36,56,57,61
313	586.1674	CH_2F_2		9R(28)		39,40
314	587.9556	$(H_2CO)_3$		10P(40)		29
315	587.9911	ClO_2		9R(36)		28
316	588.5534	CH_2DOH		10P(46)	b	
317	589.2250	DCOOD		10P(8)		28,35
318	590.6184	C_2H_3Cl		10P(22)		28
319	590.6263	C_2H_3Cl		10P(22)	g	28,61
320	593.9401	CDF_3	cascade $-qR(29,20)-1$	10R(38)		41
321	595.9417	CH_2F_2		9R(6)		39,40
322	596.8842	CH_3CH_2F		9R(24)		61

TABLE I. Continued.

No.	Frequency (GHz)	Molecule	Transition	CO_2 pump	Comment	References
323	598.1924	$(H_2CO)_3$		10P(18)		29
324	598.8937	CD_2F_2		10R(24)		37
325	602.3839	CD_2F_2		9P(28)		37
326	603.6172	$^{13}CH_2F_2$		9P(14)		47,48
327	604.2369	CH_3F	$\nu_3\ (J,K):(12,3)-(11,3)$	9P(20)		66
328	604.2973	CH_3F	$\nu_3\ (J,K):(12,2)-(11,2)$	9P(20)	g	41,43,61,67,68
329	604.3347	CH_3F	$\nu_3\ (J,K):(12,1)-(11,1)$	9P(20)		66
330	604.4650	$CHCl_2F$		9P(8)		52
331	606.0747	CH_3CN	$\nu_7\ (J,K):(33,4)-(32,4)$	9P(6)		55,61
332	607.4312	CH_3OH		10R(4)		45
333	607.9057	HCOOD		10R(40)		28,35
334	609.2846	$CHCl_2F$		9R(36)		52
335	609.4698	DCOOD		10P(8)		28,35
336	610.1083	$(H_2CO)_3$		10P(30)		29
337	611.3336	CD_3I		9R(22)		28,38
338	611.7178	C_2H_3Br		10P(16)		28,34
339	612.7748	CD_2F_2		10R(26)		37
340	613.0250	$^{18}O_3$	$\nu_1\ (J,K_a,K_c):(25,1,25)-(24,0,24)$	9R(32)		60
341	613.6653	CDF_3	$qR(30,20)\ -1$	10R(38)		41
342	613.9815	CD_2F_2		9P(42)		37
343	615.3046	CD_3I	$\nu_5\ (J,K):(50,3)-(49,3)$	9P(10)		28,38
344	615.4085	CF_2HCl		9R(32)		53
345	615.8833	CH_2F_2	$\nu_9\ (J,K_a,K_c):[22,10(9),13]-[21,8(7),14]$	10P(22)		28
346	618.4175	CH_2F_2	$\nu_9\ (J,K_a,K_c):(33,25,9)-(32,25,8)$	10R(28)		28
347	620.7378	C_2H_3Br		10P(26)		28,34
348	622.6836	CF_2HCl		9R(30)		53
349	624.1643	CD_3Cl		9P(36)		28,30
350	624.6926	DCOOH		10P(14)		28,35
351	625.7115	$^{13}CH_2F_2$		9R(40)		47,48
352	627.2291	$H^{13}COOH$	$\nu_8\ (J,K_a):(28,\simeq 12)-(27,?)$ (*tentative*)	9P(30)		27,35
353	637.3326	$CHCl_2F$		9R(34)		52
354	639.1846	CH_3OH	$(n,\tau,K;J):(0,3,4+;25)-(0,1,3-;25)$	10R(38)		45,46,61
355	639.2646	$^{13}CD_3OH$		10R(26)		69
356	640.2595	CH_2DOH		9P(26)		64
357	641.2469	$CHCl_2F$		9R(6)		52
358	642.4451	CD_3Br		10R(26)		28,51
359	642.5784	DCOOH		10P(14)		28,35
360	645.0524	$CD_3{}^{35}Cl$	$\nu_2\ (J,K):(30,10)-(29,10)$	10R(20)		28,30
361	645.2318	$H^{13}COOH$	$\nu_6\ (J,K_a,K_c):(28,3,25)-(27,3,24)$	9R(26)		27,35
362	645.5309	CH_2F_2		9P(6)		39,40
363	646.6281	CH_2CF_2	$\nu_9\ (J,K_a,K_c):[48,13(12),36]-[47,13(12),36]$	10R(20)		28
364	649.7667	$^{13}CH_3OH$	$(n,\tau,K;J):(0,3,4-;27)-(0,1,3+;27)$	9P(12)		63,70
365	649.9410	HCOOD		10P(16)		28,35
366	650.2077	N_2H_4		10P(16)		61
367	650.9275	CD_3I	$\nu_5\ (J,K):(54,3)-(53,3)$	9R(12)		28,38
368	651.8845	ClO_2		10R(24)		28
369	652.5339	$(H_2CO)_3$		9R(22)		29
370	653.6245	CH_3Br		10R(20)		28
371	653.8214	HCOOH		9R(38)	g	36,56,61
372	653.8222	$H^{12}COOH$	$\nu_6\ (J,K_a,K_c):(30,1,29)-(29,1,28)$	9R(38)	g	28,35,56,57,61
373	655.5119	DCOOD		10P(30)		28,35
374	658.7786	CD_3CN	$\nu_6\ (J,K):(42,2)-(41,2)$	9P(8)		28,55
375	661.2134	CH_3CN	$\nu_7\ (J,K):(36,7)-(35,7)$	9R(16)	g	28,55,61
376	662.6350	$^{13}CH_2F_2$		9P(16)		47,48
377	664.0284	CH_2DOH		9P(32)		64
378	664.7579	HCOOD		10P(12)		28,35
379	666.5020	$CD_3{}^{35}Cl$	$\nu_2\ (J,K):(31,10)-(30,10)$	10R(20)		28,30
380	668.3836	$H^{13}COOH$	$\nu_6\ (J,K_a,K_c):(29,3,26)-(28,3,25)$	9R(26)		27,35
381	668.5001	CH_3OH	$(n,\tau,K;J):(0,2,5L;14)-(0,2,5L;-13)$	9P(12)		45
382	670.4630	CH_3I	$\nu_6\ (J,K,F):(45,6,93/2)-(44,6,91/2)$	10P(18)	g	28,38,43,61
383	670.8672	$H^{12}COOH$		9R(16)		28,35,56
384	671.4195	$H^{12}COOH$	$\nu_6\ (J,K_a,K_c):[30,12,19(18)]-[29,12,18(17)]$	9R(22)		35,56
385	672.3318	$H^{12}COOH$	$\nu_6\ (J,K_a,K_c):(32,0,32)-(31,0,31)$	9R(20)	g	28,35
386	672.6895	CDF_3	cascade $-qR(33,13)\ +1$	10P(20)		41
387	674.6213	CD_3I	$\nu_5\ (J,K):(56,5)-(55,5)$	9R(32)		28,38
388	676.3285	$CD_3{}^{35}Cl$	$\nu_2\ (J,K):(31,7)-(30,7)$	9P(10)		28,30
389	678.0061	CH_2CHCl		10P(16)		61
390	678.7644	CD_3Br		9R(16)		28
391	679.9798	CD_2F_2		10P(32)		37

TABLE I. Continued.

No.	Frequency (GHz)	Molecule	Transition	CO_2 pump	Comment	References
392	682.8004	CH_2F_2		9R(18)		79
393	683.6665	C_2H_3Br		10P(28)		28,34
394	684.4233	$^{13}CH_2F_2$		10R(18)		47,48
395	685.3166	$H^{12}COOH$	$\nu_8\ (J,K_a,K_c)$: (30,4,26)–(29,4,25)	9P(16)		28,35
396	687.9574	N_2H_4		10P(24)		61
397	688.5030	CHD_2F		10R(38)		49
398	689.2551	CH_2F_2		9R(6)		39,40
399	691.6624	CF_2HCl		10R(34)		53
400	691.9853	DCOOH		10R(14)		28,35
401	692.1955	CD_3I		9P(28)		28,38
402	692.3815	CDF_3	$qR(34,13)\ +1$	10P(20)		41
403	692.8950	$H^{12}COOH$	$\nu_6\ (J,K_a,K_c)$: (33,1,33)–(32,1,32)	9R(20)		28,35
404	692.9514	$H^{12}COOH$	$\nu_6\ (J,K_a,K_c)$: (33,0,33)–(32,0,32)	9R(20)	g	35,36,43,56,57,58,61
405	693.5729	CF_2HCl		9R(40)		53
406	693.7884	$H^{12}COOH$	$\nu_6\ (J,K_a,K_c)$: [31,12,20(19)]–[30,12,19(18)]	9R(22)	g	28,35
407	694.3884	$CD_3{}^{79}Br$	$\nu_5\ (J,K)$: (45,1)–(44,1)	9P(18)		28,51
408	695.6915	CD_3OH		10R(34)		54
409	696.4109	CH_3CN	$\nu_4+\nu_8\ (J,K)$: (38,6)–(37,6)	10P(18)		28,55
410	696.4823	HCOOD		10P(6)		28,35
411	697.6951	HCOOD		10P(24)		28,35
412	700.7662	CF_2HCl		9R(26)		53
413	708.1371	C_2H_3Cl		10R(30)		28
414	710.1543	CH_2DOH		9R(8)		64,65
415	710.2123	CH_3CN		10P(24)		5
416	712.0058	$^{13}CH_2F_2$		9P(14)		47,48
417	712.1306	CDF_3	$qR(35,15)\ +1$	10R(46)		41
418	713.1276	$H^{12}COOH$		9R(8)		28,35
419	713.2631	CDF_3	$qR(35,35)\ +1$	10R(26)		41
420	714.0658	$(H_2CO)_3$		10P(22)		29
421	715.9876	CD_3OH		10R(36)		54
422	716.1568	$H^{12}COOH$	$\nu_6\ (J,K_a,K_c)$: [32,12,21(20)]–[31,12,20(19)]	9R(22)	g	35,36,56,57,61
423	716.7433	CH_2F_2		9R(12)		39,40
424	717.0650	CH_3OH	$(n,\tau,K;J)$: (0,1,8;15)–(0,1,8;14)	9P(36)		45,46
425	718.5056	CD_2F_2		9P(20)		37
426	719.7512	CH_3OH		9P(14)		45,46
427	721.7598	$^{13}CH_2F_2$		9P(4)		47,48
428	722.2605	CF_2HCl		9R(30)		53
429	723.5229	CF_2HCl		9R(36)		53
430	729.9328	CD_3OD		10R(12)		62,65
431	736.0596	CH_2F_2	$\nu_4\ (J,K_a,K_c)$: (38,29,9)–(37,29,8)	10P(14)		61
432	736.8120	CHD_2F		10P(28)		2
433	739.1610	$H^{12}COOH$	$\nu_6\ (J,K_a,K_c)$: [33,9,25(24)]–[32,9,24(23)]	9R(18)	g	35,36,56,61
434	739.3075	CH_3CH_2F		9R(30)		61
435	739.3403	CHDO	$\nu_5\ (J,K_-,K_+)$: (12,0,12)–(11,0,11)	9P(16)		71
436	742.4704	$^{13}CH_2F_2$		9P(32)		47,48
437	742.5939	CH_2F_2		9P(4)	c	79
438	746.7847	CH_2F_2		9P(38)	c	79
439	750.8176	$^{13}CH_2F_2$		9R(34)		47,48
440	757.6019	HCOOD		10R(12)		28,35
441	758.6825	DCOOD		10R(10)		28,35
442	759.5433	CH_2F_2		9P(6)		39,40
443	761.6083	$H^{12}COOH$	$\nu_6\ (J,K_a,K_c)$: [34,9,26(25)]–[33,9,25(24)]	9R(18)	d,g	28,35,43,56,57,58,61
444	761.8888	$H^{13}COOH$	$\nu_6\ (J,K_a,K_c)$: (34,7,27)–(33,7,26)	9P(32)		27,35
445	764.6426	CH_3OH	$(n,\tau,K;J)$: (0,1,8;16)–(0,1,8;15)	9P(36)		45,46,61
446	765.3846	HCOOD		10R(38)		28,35
447	765.8290	$^{13}CH_2F_2$		9R(30)		47,48
448	768.8820	DCOOD		10R(12)		28,35
449	771.3654	CDF_3	$qR(38,24)\ -1$	10R(42)		41
450	772.1170	CDF_3	$qR(38,32)\ +1$	10R(32)		41
451	772.5420	C_2H_5OH		9P(32)		72
452	773.5399	CH_2DOH		9P(40)		64,65
453	774.7261	CF_2HCl		9R(18)		53
454	775.9824	CH_3OH		9P(14)		45,46
455	776.5891	CD_3OH		10R(34)		54
456	776.8471	CH_2CHCl		10P(22)		61
457	777.2948	CF_2HCl		9R(18)		53
458	778.9467	$(H_2CO)_3$		9R(30)		29
459	780.0615	CHD_2F		10P(28)		49
460	782.1667	$CD_3{}^{35}Cl$	$\nu_5\ (J,K)$: (36,0)–(35,0)	9R(34)		28,30
461	783.2267	CF_2HCl		10R(40)		53

TABLE I. Continued.

No.	Frequency (GHz)	Molecule	Transition	CO_2 pump	Comment	References
462	783.4860	CH_2F_2		9P(10)		39,40
463	784.0631	$H^{13}COOH$	$\nu_8 - (J,K_a) : (35,>8)-(34,?)$ tentative	9P(26)		27,35
464	784.8060	CH_2F_2		9R(36)		39,40
465	785.5872	$H^{13}COOH$	$\nu_8\ (J,K_a) : (35,8)-(34,8)$ (tentative)	9P(24)		27,35
466	787.7555	DCOOD		10R(12)		28,35
467	791.2604	CD_2F_2		10P(22)		37
468	793.6931	$^{13}CH_2F_2$		9R(10)		47,48
469	797.3625	$CHCl_2F$		9P(16)		52
470	798.2866	CH_2F_2	$\nu_4\ (J,K_a,K_c) : (43,31,12)-(42,31,11)$	10P(12)		61
471	798.5795	CHD_2F		9R(6)		49
472	801.3996	CH_2DOH		10P(46)		64,65
473	804.0129	CF_2HCl		9R(22)		53
474	804.1348	CH_3CN	$\nu_4\ (J,K) : (44,0)-(43,0)$	10P(20)		28,55
475	810.3205	HCOOD		10R(28)		28,35
476	812.1954	CH_3OH		9P(16)		45,46
477	812.7500	N_2H_4		9R(18)		4
478	815.9859	CD_2F_2		10R(14)		37
479	817.7083	$CD_3{}^{79}Br$	$\nu_5\ (J,K) : (53,5)-(52,5)$	9P(14)		28,51
480	818.4946	CF_2HCl		9R(30)		53
481	819.4058	CD_2F_2		9R(34)		37
482	819.7205	$CHCl_2F$		9P(18)		52
483	822.5122	CD_2O		10P(28)		71,73
484	827.1884	CDF_3	ν_2 line	9R(24)		41
485	829.9183	CDF_3	$qR(41,11)+1$	10P(24)		41
486	831.3569	CF_2HCl		9R(14)		53
487	831.5927	$^{13}CH_2F_2$		9P(16)		47,48
488	832.6350	CH_2F_2		9R(8)		79
489	834.2359	$^{13}CH_2F_2$		9R(22)		47,48
490	837.6408	CH_2F_2		9R(14)		79
491	837.7194	$^{13}CH_2F_2$		9R(20)		47,48
492	844.1859	CH_2F_2		9P(8)		39,40
493	844.1860	$^{13}CH_2F_2$		9P(8)		47,48
494	846.4503	CD_3OD		10R(16)		62,65
495	849.5064	CD_2F_2		10R(34)		37
496	856.7037	CH_3NH_2		10R(20)		4
497	858.0533	CH_3Cl		10R(18)		79
498	865.2331	CH_3OH		9P(22)		45,46
499	869.5227	CD_3OD		10R(4)		62,65
500	870.1719	$^{13}CH_2F_2$		9R(16)		47,48
501	876.2613	CD_2F_2		9P(44)		37
502	880.1204	$^{13}CD_3OH$		10P(16)		69
503	880.8186	CH_2DOH		10R(32)		64,65
504	880.9656	$CHCl_2F$		9P(20)		52
505	884.4381	$^{13}CH_3OH$	$(n,\tau,K;J) : (0,1,9;19)-(0,1,9;18)$	9P(22)		63,70
506	887.5511	CH_2F_2		9R(10)		66
507	889.3435	CF_2HCl		9R(32)		53
508	891.5863	CH_2DOH		9P(36)		64
509	893.0136	DCOOD		9R(8)		28,35
510	893.6569	CF_2HCl		9R(16)		53
511	897.7581	CH_3Cl		9P(42)		79
512	897.7819	$^{13}CH_2F_2$		9P(36)		47,48
513	899.5717	$^{13}CD_3OH$		10P(16)		69
514	901.3512	$^{13}CH_3OH$	$(n,\tau,K;J) : (0,3,6;24)-(0,1,5;24)$	10R(16)		63,70
515	903.8894	N_2H_4		9P(12)		61
516	905.4770	CHDO	$\nu_5\ (J,K-,K+) : (14,4,11)-(13,4,10)$	10P(30)		71
517	905.7426	CD_2F_2		9P(34)		37
518	908.4086	CDF_3	$qR(45-13)+1$	10R(8)		41
519	911.3327	CF_2HCl		9R(28)		53
520	912.7297	DCOOH		10P(22)		28,35
521	918.4170	CH_2F_2		9R(14)		39,40
522	924.0784	CD_2O		10P(24)		28
523	924.8858	$^{13}CD_3OD$		10R(14)		74
524	924.6368	CD_2F_2		9P(40)		37
525	929.7268	CH_2DOH		9P(12)		64
526	932.7413	$^{13}CD_3OD$		10R(12)		74
527	935.1075	CD_2F_2		10R(44)		37
528	939.0003	CD_2O	$\nu_6\ (J,K-,K+) : (16,3,14)-(15,3,13)$	9P(32)		71
529	942.5074	$^{13}CH_2F_2$		9R(12)		47,48
530	945.5625	CD_2F_2		9P(40)		37
531	947.7237	$^{13}CH_2F_2$		9R(24)		47,48

TABLE I. Continued.

No.	Frequency (GHz)	Molecule	Transition	CO_2 pump	Comment	References
532	952.1850	CH_3NH_2		9R(4)		61
533	952.2039	CD_3OD		10R(10)		62,65
534	952.7933	CD_2F_2		9R(10)		37
535	955.3681	$H^{13}COOH$		9P(6)		27,35
536	955.3703	$H^{13}COOH$		9P(6)		27,35
537	960.0245	$^{13}CH_2F_2$		9P(24)		47,48
538	962.2500	HCOOH		10R(22)		26
539	963.3022	$^{13}CH_2F_2$		9R(8)		47,48
540	963.7314	N_2H_4		9P(20)		61
541	969.5968	CH_2F_2		9R(22)		79
542	972.4187	CH_2DOH		10R(34)	b	
543	973.2243	CH_2DOH		9P(14)		64
544	976.5437	$^{13}CH_2F_2$		9R(40)		47,48
545	979.5445	CF_2HCl		9R(24)		53
546	980.5916	CH_3OD		9R(8)		20,65
547	985.8897	DCOOD		10R(24)		28,35
548	991.7778	$H^{12}COOH$	$\nu_6\ (J,K_a,K_c)$: (44,6,39)–(43,6,38)	9R(4)	g	35,36,56,57,58,61
549	992.7089	CH_3OH		9P(14)		45,46
550	993.8299	$^{13}CH_2F_2$		10R(4)		47,48
551	995.0778	N_2H_4		10R(12)		61
552	997.7253	CH_2F_2		9P(18)	c	79
553	998.4879	$^{13}CH_2F_2$		10R(38)		47,48
554	998.5321	$^{13}CH_2F_2$		9R(36)		47,48
555	1003.5366	CD_3OD		10R(24)		62,65
556	1004.4306	CH_2F_2		9R(36)		79
557	1005.3033	CH_2F_2		9R(36)		39,40
558	1005.8500	CF_2HCl		9R(24)		53
559	1014.0477	CH_2DOH		10R(34)		64,65
560	1014.8810	CH_2DOH		9P(10)		64
561	1016.8972	CH_3OD		9R(8)		20,65
562	1020.0440	CH_2F_2		9P(20)		39,40
563	1020.3211	CH_3OH		10R(10)		45,46
564	1020.9247	$CD_3{}^{37}Cl$		9P(24)		28,30
565	1026.1893	CH_3OH	$(n,\tau,K;J)$: (0,2,5×;10)–(0,2,5L;10)	9P(38)		45,46
566	1030.8799	CH_2F_2		9R(24)		79
567	1031.3844	CD_3OD		10R(14)		75
568	1035.5527	CH_2F_2	$\nu_9\ (J,K_p,K_0)$: (35,6,30)–(34,5,29)	9P(4)		39,40
569	1036.8448	CH_2F_2		9P(24)	c	79
570	1041.2794	CH_2F_2		9R(26)		79
571	1042.1504	CH_2F_2	$\nu_9\ (J,K_p,K_0)$: (18,14,4)–(18,13,5)	9R(34)		39,40
572	1043.4545	CD_3OH		10P(18)		54
573	1045.5780	CD_3OH		10P(24)		54
574	1046.7682	CD_2F_2		9P(8)		37
575	1047.5023	CD_3OH		9P(40)		54
576	1047.6576	CH_3OH		10R(48)		45
577	1054.2918	CH_2F_2		9R(18)		79
578	1056.4147	CH_2F_2		9R(40)		79
579	1066.6754	CH_2F_2		9P(14)	c	79
580	1067.1272	CH_3OH		9R(18)		45,46
581	1068.7337	CD_2F_2		9P(30)		37
582	1069.7714	$^{13}CH_3OH$	$(n,\tau,K;J)$: (0,3,6;23)–(0,3,6;22)	10R(16)		63,70
583	1069.8534	$^{13}CH_3OH$	$(n,\tau,K;J)$: (0,2,7;23)–(0,2,7;22)	10R(16)		63,70
584	1074.4710	$^{13}CH_2F_2$		9P(22)		47,48
585	1075.2771	CH_3OH	$(n,\tau,K;J)$: (0,2,5×;10)–(0,2,5u;10)	9P(38)		45,46
586	1076.8428	CD_2O		10P(8)		28
587	1083.3951	CD_3OH		10P(28)		54
588	1091.0447	CD_2F_2		10R(26)		37
589	1093.1547	CH_3OH		10R(46)		45
590	1095.0770	$^{13}CH_2F_2$		9P(26)		47,48
591	1098.1259	CH_2DOH		9P(6)		64,65
592	1100.8067	CH_2F_2	$\nu_9\ (J,K_p,K_0)$: (40,15,25)–(40,14,26)	9P(10)		39,40
593	1101.1594	CH_2DOH		9R(24)		64,65
594	1107.3379	CD_3OD		9R(8)		62,65
595	1110.3199	CH_2F_2		9R(22)		39,40
596	1116.2455	$^{13}CH_3OH$	$(n,\tau,K;J)$: (0,2,7;24)–(0,2,7;23)	10R(16)		63,68
597	1118.3692	CH_2F_2		9R(26)		79
598	1119.3680	CD_2F_2		9P(18)		37
599	1120.9576	CH_3OH	$(n,\tau,K;J)$: (0,2,5×;25)–(0,2,5L;25)	10R(34)		45,46
600	1123.3820	$^{13}CH_2F_2$		9R(24)		47,48
601	1123.9327	CH_2DOH		9P(32)		64

TABLE I. Continued.

No.	Frequency (GHz)	Molecule	Transition	CO_2 pump	Comment	References
602	1132.1406	N_2H_4		10R(20)		61
603	1132.3201	CD_3OH		10R(34)		54
604	1133.2770	CH_3OH	$(n,\tau,K;J):(0,1,6\times;10)-(0,2,5U;10)$	9P(34)		45,46
605	1136.9420	CH_3OH	$(n,\tau,K;J):(0,1,6\times;9)-(0,2,5U;9)$	9P(34)		45,46
606	1143.1631	CH_2F_2		9R(38)		79
607	1145.4301	CH_2F_2		9P(38)		39,40
608	1152.8600	$^{13}CH_2F_2$		10R(20)		47,48
609	1160.0278	CD_3OH		10P(22)		54
610	1160.0718	$H^{13}COOH$		9P(16)		27,35
611	1170.9410	CH_2F_2		9P(24)		39,40
612	1176.5700	$^{13}CH_2F_2$		9P(4)		47,48
613	1180.0925	CH_3OH	$(n,\tau,K;J):(0,1,6\times;9)-(0,2,5L;9)$	9P(34)		45,46
614	1181.5898	CD_3OH		10R(36)		54
615	1182.3662	CH_3OH	$(n,\tau,K;J):(0,1,6\times;10)-(0,2,5L;10)$	9P(34)		45,46
616	1188.0687	CH_2F_2		9R(42)		79
617	1190.0691	CH_3OH		10R(44)		45
618	1192.3383	CH_3OH		9R(18)		45,46
619	1193.7273	CH_3OH	$(n,\tau,K;J):(0,3,4+;25)-(0,3,4+;24)$	10R(38)		45,46,61
620	1195.4339	CH_3OH	$(n,\tau,K;J):(0,2,5\times;25)-(0,2,5\times;24)$	10R(34)		45,46
621	1198.5101	CH_3NH_2		9P(24)		4
622	1200.5127	CH_2DOH		10P(34)		64,65
623	1202.0932	CD_2F_2		10R(22)		37
624	1205.8960	$^{13}CH_2F_2$		9R(26)		47,48
625	1208.2460	CH_2DOH		10P(34)		64,65
626	1208.3139	CD_2F_2		10R(16)		37
627	1210.4088	CH_2F_2		9R(34)		79
628	1220.3950	$^{13}CH_2F_2$		9P(28)		47,48
629	1229.4218	CD_2O	$\nu_6\ (J,K-,K+):[21,6,15(16)]-[20,6,14(15)]$	9R(24)		71
630	1231.9110	CH_2F_2		9R(30)		79
631	1234.4904	CH_3OH		10R(32)		45
632	1236.3969	CH_3OH		10R(34)		45,46
633	1256.8720	$^{13}CH_3OH$	$(n,\tau,K;J):(0,3,4-;27)-(0,3,4-;26)$	9P(12)		63,68
634	1260.9142	CH_2F_2		9P(6)	c	79
635	1262.1620	$^{13}CH_3OH$		9P(12)		63
636	1267.0815	CH_2F_2		9R(6)		39,40
637	1267.0913	CH_2F_2		9R(42)		79
638	1267.1310	CH_2F_2		9R(6)		39,40
639	1267.4590	$^{13}CH_3OH$		9P(10)		63
640	1269.7236	CD_2F_2		9R(34)		37
641	1272.1714	CH_2F_2	$\nu_9\ (J,K_p,K_0):(18,17,1)-(18,16,2)$	9R(32)		39,40
642	1281.6258	N_2H_4		10R(8)		61
643	1282.8920	CD_2F_2		9P(10)		37
644	1285.9685	CD_2O	$\nu_6\ (J,K-,K+):(21,3,18)-(20,3,17)$	9R(14)		71
645	1286.9995	CH_3OH	$(n,\tau,K;J):(0,2,10;27)-(0,2,10;26)$	9R(10)	a	21,45,46,61
646	1287.8322	CH_3OH		9R(22)		45,46
647	1302.8458	CH_2F_2		9R(42)		39,40
648	1308.7555	CD_2F_2		10R(20)		37
649	1316.8387	CD_3OD		10R(10)		62,65
650	1316.8605	CH_2F_2		9P(18)		39,40
651	1324.7719	CH_2DOH		9P(46)		64,65
652	1329.3629	CH_3OH		9R(8)		45,46
653	1337.0125	CH_2DOH		10P(36)		64,65
654	1349.1001	CD_3OH		10R(34)		54
655	1368.3154	CH_2DOH		9R(24)		64,65
656	1370.4850	CH_3NH_2		9P(24)		4
657	1373.5133	CD_2F_2		10R(38)		37
658	1376.2711	O_3	$\nu_3\ (J,K_a,K_c):(16,8,9)-(16,7,10)$	9P(30)		60
659	1385.6461	$^{13}CD_3OD$		10P(24)		74
660	1391.9721	CH_3OD		9R(14)		20,65
661	1393.8569	CD_3OH		10P(52)		54
662	1396.2388	CD_2F_2		10R(36)		37
663	1397.0050	$^{13}CH_2F_2$		9R(34)		47,48
664	1397.1186	CH_2F_2		9R(34)		39,40
665	1404.4269	CH_3OH		9P(22)		45,46
666	1405.1630	$^{13}CH_2F_2$		9R(44)		47,48
667	1418.7010	CH_3OH	$(n,\tau,K;J):(0,2,5\times;8)-(0,2,5U;7)$	9P(12)		45,46
668	1419.0493	CH_3OH		10R(4)		45,46
669	1428.0576	CH_3OH	$(n,\tau,K;J):(0,3,9;30)-(0,3,9;29)$	9R(14)		45,46
670	1432.8178	$^{13}CD_3OD$		10R(12)		74

TABLE I. Continued.

No.	Frequency (GHz)	Molecule	Transition	CO_2 pump	Comment	References
671	1438.4601	$^{13}CH_3OH$	$(n,\tau,K;J)$: $(1,1,3-;31)-(1,1,3-;30)$	9P(10)		63,70
672	1442.4543	CD_2F_2		10R(38)		37
673	1449.7780	CH_3OH	$(n,\tau,K;J)$: $(0,2,5\times;8)-(0,2,5L;7)$	9P(12)		45,46
674	1450.4631	CH_2DOH		9P(14)		64
675	1455.0000	$^{13}CH_2F_2$		10R(18)		47,48
676	1455.4348	CH_2F_2		9R(26)		79
677	1472.1994	$^{13}CH_3OH$	$(n,\tau,K;J)$: $(0,2,7;24)-(0,3,6;24)$	10R(16)		63,70
678	1480.7129	CH_2F_2		9R(6)		39,40
679	1496.7570	$^{13}CH_2F_2$		9P(16)		47,48
680	1509.0402	CH_3OH	$(n,\tau,K;J)$: $(0,2,5\times;10)-(0,2,5L;9)$	9P(38)		45,46
681	1514.5626	CH_3NH_2		9P(24)		4
682	1518.7950	$^{13}CH_2F_2$		9P(20)		47,48
683	1521.4309	$^{13}CD_3OH$		10R(26)		69
684	1525.1641	CH_3OH		9P(44)		45
685	1533.4999	CH_2DOH		9P(36)		64
686	1536.1530	$^{13}CH_2F_2$		9R(20)		47,48
687	1541.7647	CH_2F_2		9R(12)		39,40
688	1542.5246	CHDO		9P(8)		71
689	1544.8187	CH_3OH	$(n,\tau,K;J)$: $(0,3,9;30)-(0,1,8;30)$	9R(14)		45,46
690	1546.0834	CH_2F_2		9R(22)		39,40
691	1549.3400	$^{13}CH_2F_2$		9P(22)		47,48
692	1551.9387	CH_2F_2		9R(26)		79
693	1552.1901	CH_3OH	$(n,\tau,K;J)$: $(0,2,5\times;10)-(0,2,5U;9)$	9P(38)		45,46
694	1554.0760	N_2H_4		10P(24)		4
695	1555.0201	CD_2F_2		9P(8)		37
696	1562.6559	CH_2F_2		9P(22)		39,40
697	1564.5187	CH_3OH		10R(10)		45,46
698	1566.6728	CD_3OH		10R(34)		54
699	1571.8497	CH_3OH	$(n,\tau,K;J)$: $(0,1,6\times;9)-(0,2,5U;8)$	9P(34)		45,46
700	1578.3392	CH_3OH	$(n,\tau,K;J)$: $(0,1,3+;28)-(0,2,2+;27)$	9R(10)		66
701	1579.2503	CD_2F_2		10R(34)		37
702	1591.0532	CD_3OH		10P(42)		54
703	1591.1612	CH_2DOH		10P(26)		64,65
704	1596.1749	CD_2F_2		10R(14)		37
705	1604.6477	CH_3F		9R(10)	c	76
706	1609.0267	CH_3OH	$(n,\tau,K;J)$: $(0,1,6\times;9)-(0,2,5L;8)$	9P(34)		45,46
707	1611.4140	$^{13}CH_2F_2$		9P(38)		47,48
708	1611.4219	CH_3OH		9R(18)		45,46
709	1616.1284	CH_3OH	$(n,\tau,K;J)$: $(0,1,6\times;10)-(0,2,5U;9)$	9P(34)		45,46
710	1622.5552	CD_3OD		10R(24)		62,65
711	1626.6026	CH_2F_2	$\nu_9\ (J,K_p,K_0)$: $(18,17,1)-(17,16,2)$	9R(32)		39,40
712	1632.6669	CH_2DOH		9P(10)		64
713	1635.6280	$^{13}CH_2F_2$		9P(28)		47,48
714	1642.1019	CD_3OH		9R(14)		54
715	1643.7690	$^{13}CH_2F_2$		10R(20)		47,48
716	1647.8774	N_2H_4		10P(6)		61
717	1658.6899	CD_3OH		10R(34)		54
718	1659.2786	CH_3OH	$(n,\tau,K;J)$: $(0,1,6\times;10)-(0,2,5L;9)$	9P(34)		45,46
719	1668.0350	CH_3OH		10R(4)		45,46
720	1726.5485	$^{13}CD_3OD$		10R(20)		74
721	1734.4464	CH_2DOH		9P(12)		64
722	1745.4395	$^{13}CH_3OH$		10R(18)		63
723	1757.5263	CH_3OH	$(n,\tau,K;J)$: $(0,1,8;16)-(0,2,7;16)$	9P(36)	e,g	17,21,45,46,61,77
724	1783.6011	CD_3OH		10R(34)		54
725	1788.8766	CH_3OH		10R(40)		45,46
726	1789.3659	CH_2DOH		9P(18)		64
727	1791.3848	CH_2DOH		9P(32)		64
728	1796.4617	CD_2F_2		9R(10)		37
729	1798.6470	CH_2F_2	$\nu_4+\nu_9\ (J,K_p,K_0)$: $(33,23,10)-(33,22,11)$	9R(22)		39,40
730	1799.1393	CH_2F_2	$\nu_4+\nu_9\ (J,K_p,K_0)$: $(38,23,15)-(38,22,16)$	9R(20)		39,40
731	1810.2943	CD_3OD		10R(22)		62,65
732	1818.9640	$^{13}CH_2F_2$		9R(4)		47,48
733	1819.3140	CH_3OH	$(n,\tau,K;J)$: $(0,2,10;27)-(0,3,9;27)$	9R(10)		45,46
734	1819.7203	CH_2DOH		9R(8)		64,65
735	1820.2615	CH_3OH		9P(24)		45,46
736	1820.7150	$^{13}CH_2F_2$		9P(12)		47,48
737	1821.3352	CH_3OH		9P(16)		45,46
738	1821.7355	CH_3OH		9P(14)	b	
739	1822.3627	CH_3OH		9P(14)		45,46

TABLE I. Continued.

No.	Frequency (GHz)	Molecule	Transition	CO_2 pump	Comment	References
740	1832.7686	CH_3OH	$(n,\tau,K;J)$: (0,2,5L;14)–(0,3,4;13)	9P(12)		45,46
741	1837.8610	CH_2F_2		9R(22)		79
742	1838.8393	CH_3OH	$(n,\tau,K;J)$: (0,3,4 + ;25)–(0,1,3 + ;24)	10R(38)		45,46,61
743	1848.0838	CH_3OH	$(n,\tau,K;J)$: (0,3,10;18)–(0,1,9;18)	9P(36)		45
744	1877.5085	CH_3OH		9R(26)		45,46
745	1882.9063	CH_2DOH		10R(34)		64,65
746	1885.9593	CH_2F_2		9P(20)		39,40
747	1891.2742	CH_2F_2	ν_9 (J,K_p,K_0) : (40,15,25)–(39,14,26)	9P(10)		39,40
748	1898.2799	$^{13}CH_3OH$	$(n,\tau,K;J)$: (0,3,4 – ;27)–(0,1,3 – ;26)	9P(12)		63,70
749	1944.6796	CH_2F_2		9P(24)	c	79
750	1950.5816	$^{13}CD_3OH$		9R(28)		69
751	1956.9358	CH_2F_2		9P(28)	c	79
752	1971.3372	$^{13}CH_3OH$	$(n,\tau,K;J)$: (0,3,6;23)–(0,1,5;22)	10R(16)		63,70
753	1982.0506	CH_3OH		9R(26)		45,46
754	1987.7989	CH_2DOH		10R(34)		64,65
755	1991.0283	CH_2DOH		10P(26)		64,65
756	1992.7952	CD_2F_2		10R(18)		37
757	2003.7883	CH_2DOH		10R(32)		64,65
758	2006.8052	CH_2DOH		10P(36)		64,65
759	2008.3601	$^{13}CH_3OH$	$(n,\tau,K;J)$: (0,1,9;19)–(0,2,8;19)	9P(22)		63,70
760	2017.2185	$^{13}CD_3OD$		10R(30)		74
761	2017.5761	$^{13}CH_3OH$	$(n,\tau,K;J)$: (0,3,6;24)–(0,1,5;23)	10R(16)		63,70
762	2027.7526	CH_3NH_2		9P(24)		61
763	2034.5736	CD_3OH		10P(32)		54
764	2048.8036	$^{13}CD_3OH$		10R(26)		69
765	2052.0041	$^{13}CH_3OH$	$(n,\tau,K;J)$: (1,1,3 – ;31)–(1,2,2 + ;31)	9P(10)		63,70
766	2058.1418	CH_3OD		9P(30)		65
767	2059.5316	$^{13}CD_3OH$		10R(24)		69
768	2063.9411	CH_3OH		10R(32)		45
769	2066.3791	CH_2F_2		9P(24)	c	79
770	2080.1893	CD_3OH		10P(18)		54
771	2093.7288	CH_2F_2		9R(42)		79
772	2135.1930	$^{13}CH_2F_2$		9R(38)		47,48
773	2152.6624	CD_2F_2		10R(20)		37
774	2168.0000	$^{13}CH_2F_2$		9R(22)		47,48
775	2188.9290	CD_3OD		10R(46)		75
776	2194.2369	CD_3OH		10R(14)		54
777	2207.0583	CH_2DOH		9R(8)		64,65
778	2212.1110	$^{13}CH_2F_2$		9R(44)		47,48
779	2216.2635	CH_2F_2		9P(24)		39,40
780	2217.8499	CH_2DOH		10R(32)		64,65
781	2217.8633	CH_2DOH		10R(32)		64,65
782	2237.2964	CH_2F_2		9P(22)		39,40
783	2252.0542	CH_3OH		9P(24)		45,46
784	2278.7030	CD_3OH		10R(32)		54
785	2314.1113	CH_3OH	$(n,\tau,K;J)$: (0,2,5×;25)–(0,2,5L;24)	10R(34)		45,46
786	2340.2918	$^{13}CD_3OD$		10R(16)		74
787	2341.5089	CD_3OH		10R(34)		54
788	2348.4384	$^{13}CD_3OH$		10R(22)		69
789	2360.1748	$^{13}CD_3OH$		10P(8)		69
790	2369.0567	CH_2F_2		9P(30)	c	79
791	2402.2240	CD_3OD		10R(26)		62,65
792	2409.2933	CH_2DOH		10P(34)		64,65
793	2412.7579	$^{13}CD_3OD$		9P(24)		74
794	2447.9685	CH_2F_2	$\nu_4 + \nu_9$ (J,K_p,K_0) : (33,23,10)–(33,22,11)	9R(22)		39,40
795	2447.9746	CH_2F_2		9P(8)		39,40
796	2451.2031	CD_3OD		10R(28)		62,65
797	2479.6222	CH_3OH		10R(44)		45
798	2488.5534	CD_2F_2		10R(36)		37
799	2518.0677	CD_3OD		10R(26)		62,65
800	2522.7816	CH_3OH	$(n,\tau,K;J)$: (0,1,8;16)–(0,2,7;15)	9P(36)	a,g,h	17,21,45,46,61
801	2528.7728	$^{13}CD_3OD$		10R(14)		74
802	2540.3310	$^{13}CH_3OH$	$(n,\tau,K;J)$: (1,3,10;21)–(1,1,9;21)	9P(22)		63,70
803	2541.4856	CH_3OH		9P(14)		45,46
804	2546.4950	CH_2F_2	$\nu_4 + \nu_9$ (J,K_p,K_0) : (38,23,15)–(38,22,16)	9R(20)		39,40
805	2557.3654	CH_3OD		9P(26)		61,65
806	2560.4670	CH_2DOH		9P(32)		64
807	2585.8568	CH_2F_2		9P(8)	c	79
808	2588.3617	$^{13}CH_3OH$	$(n,\tau,K;J)$: (0,2,7;24)–(0,3,6;23)	10R(16)		63,70

TABLE I. Continued.

No.	Frequency (GHz)	Molecule	Transition	CO_2 pump	Comment	References
809	2635.9580	CH_3OH		9R(8)		45,46
810	2654.3107	CH_3OH		9P(44)		45
811	2664.0583	CH_2DOH		9P(12)		64
812	2707.7493	CH_3OH	$(n,\tau,K;J)$: (0,3,10;18)–(0,1,9;17)	9P(36)		45
813	2714.7147	$^{13}CH_3OH$		10R(18)		63
814	2726.9235	$^{13}CD_3OD$		10R(16)		74
815	2727.2117	$^{13}CD_3OD$		10R(16)		74
816	2742.9460	CH_2F_2		9P(24)		39,40
817	2751.8729	CH_2DOH		9P(32)		64
818	2754.9957	CH_2DOH		9P(12)		64
819	2758.7817	CD_3OH		10P(10)		54
820	2787.7894	CD_3OD		10R(12)		62,65
821	2841.1429	CH_2F_2		9P(16)		39,40
822	2851.1692	$^{13}CH_3OH$		10R(18)		63
823	2894.1323	$^{13}CH_3OH$		10R(26)		63
824	2897.0824	$^{13}CH_3OH$	$(n,\tau,K;J)$: (0,1,9;19)–(0,2,8;18)	9P(22)		63,70
825	2907.0889	CH_3OD		9P(30)		61,65
826	2938.4651	CH_2DOH		9P(16)		64
827	2973.9406	CH_3OH	$(n,\tau,K;J)$:(0,3,9;30)–(0,1,8;29)	9R(14)		45,46
828	2992.9570	CH_3OH		10R(32)		45
829	3002.0875	CH_3OH		10P(16)		45
830	3074.2100	CH_3OH		10R(40)		45,46
831	3105.9368	CH_3OH	$(n,\tau,K;J)$: (0,2,10;27)–(0,3,9;26)	9R(10)	a,g	21,45,46,61
832	3137.5106	CH_2F_2		9R(12)		39,40
833	3235.2536	CH_3OH		10R(34)		45,46
834	3239.4616	CH_3OH		9P(22)		45
835	3456.1612	CD_3OH		10R(34)		54
836	3476.2825	CH_3OH		9R(8)		45,46
837	3481.4330	$^{13}CH_3OH$	$(n,\tau,K;J)$: (1,1,3 – ;31)–(1,2,2 – ;30)	9P(10)		63,70
838	3502.2102	CH_3OH		9P(40)		45,46
839	3513.8534	$^{13}CH_3OH$	$(n,\tau,K;J)$: (1,3,10;21)–(1,1,9;20)	9P(22)		63,70
840	3551.8058	$^{13}CD_3OH$		10R(22)		69
841	3675.8599	CD_3OH		10R(16)		54
842	3848.1855	CH_3OH		10R(16)		45,46
843	3868.8189	$^{13}CH_3OH$		10R(26)		63
844	3873.0051	CH_3OH		9R(8)		45,46
845	3982.6311	$^{13}CD_3OD$		9R(24)		74
846	4080.6372	$^{13}CD_3OH$		10R(20)		69
847	4089.5796	CH_3OH		9P(40)		45,46
848	4223.0620	CD_3OH		10R(8)		54
849	4251.6740	CH_3OH	$(n,\tau,K;J)$: (1,2,5;9)–(0,1,6;10)	9P(34)	f,g	21,45,46,61
850	4302.4449	CH_3OH		10R(16)		45,46
851	4441.6752	CH_3OH		9R(18)		45,46
852	4442.7248	CD_3OH		10R(30)		54
853	4730.8664	CH_3OH	$(n,\tau,K;J)$: (1,2,5;9)–(0,1,6;9)	9P(34)		45,46
854	4751.3409	$^{13}CH_3OH$		9P(12)		63
855	4761.1824	CH_3OH		10R(16)		45,46
856	4865.7098	CH_3OH		9R(18)		45,46
857	4982.1531	CH_3OH		9P(40)		45,46
858	5414.3441	CH_3OH		9P(40)		45,46
859	5566.0527	CH_3OH		10R(36)		45,46
860	6860.6642	CD_3OH		10R(18)		54
861	7110.9814	CH_3OH		9P(32)		45,46
862	7249.2660	CD_3OH		10R(18)		54
863	7509.0362	CH_3OH	$(n,\tau,K;J)$: (1,2,5;9)–(1,2,5;8)	9P(34)		45,46
864	7919.6602	CH_3OH		9P(32)		45,46

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[a] This line has been generated and measured in a Fabry–Perot cavity in Ref. 46. The average difference with previous measurements in waveguide cavities is 0.3 MHz, the maximum discrepancy is 0.7 MHz.

[b] We are greatly indebted to Professor M. Yamanaka for pointing out these lines to our attention.

[c] Pumped by $^{12}C^{18}O_2$.

[d] Measured in five different laboratories. The spread is larger than the declared experimental uncertainties. This stresses the importance of a careful design of the apparatus and of extremely careful experimental procedures for obtaining a reproducibility of a few parts in 10^7, as stated in the text.

[e] The frequency of this line has been carefully remeasured, checking for possible pressure shifts (Ref. 77).

[f] The frequency of Ref. 46 reflects a better determination of the line center.

[g] Different frequency values are available from different measurements as reported in the following list. The values reported in the table correspond either to the most accurate measurement or to the average, when the accuracies are comparable.

Frequency	Reference
239.1190 (3)	43
239.1193 (2)	44
398.2991 (5)	28
398.2996 (5)	50
402.9205 (5)	36
402.9196 (7)	57
402.9210 (3)	58
403.7213 (4)	36
403.7216 (10)	56
403.7221 (2)	58
408.6736 (5)	28
408.6738 (5)	50
428.6278 (5)	28
428.6284 (2)	44
428.6285 (3)	46
447.7649 (4)	36
447.7650 (7)	56
447.7660 (5)	61
452.3020 (5)	28
452.3015 (5)	61
472.5075 (5)	28
472.5078 (5)	61
488.0345 (5)	28
488.0347 (5)	61
497.5916 (5)	25
497.5918 (2)	46
525.4275 (5)	28
525.4274 (5)	41
525.4283 (3)	43
525.4275 (3)	46
527.8543 (5)	28
527.8539 (5)	61
540.7829 (5)	28
540.7851 (5)	61
561.7475 (5)	28
561.7485	35
581.9297 (5)	28
581.9303	35
584.3880 (4)	36
584.3882 (7)	56
584.3869 (5)	61
590.6265 (5)	28
590.6263 (5)	61
604.2971 (5)	41
604.2973 (5)	43
604.2971 (5)	61
604.2975 (2)	68
653.8215 (6)	36
653.8222 (7)	56
653.8214 (5)	61
661.2118 (6)	28
661.2134 (5)	61
670.4633 (6)	28
670.4630 (3)	43
670.4624 (5)	61
692.9510 (5)	36
692.9514 (2)	43
692.9495 (10)	56
692.9517 (2)	58
692.9505 (5)	61
693.7884 (5)	28
693.7885	35
716.1574 (7)	36
716.1558 (7)	56
716.1564 (5)	61
739.1613 (7)	36
739.1610 (5)	61
761.6100 (5)	28
761.6077 (3)	43
761.6076 (5)	56
761.6098 (2)	58
761.6065 (5)	61
991.7758 (9)	36
991.7769 (10)	56
991.7777 (5)	58
991.7778 (5)	61
1757.5260 (60)	17
1757.5263	46
1757.5263	77
2522.7800 (100)	17
2522.7816 (3)	46
2522.7820 (3)	78
3105.9368 (5)	21
3105.9368 (3)	46
4251.6687 (50)	21,61
4251.6740 (20)	46
4251.6740 (7)	78

[h] A more accurate value for this frequency, 2522.782567(70) GHz, has been recently (December 1985) obtained by tunable FIR spectroscopy by Evenson, Inguscio, Jennings, and Zink. In Pisa the technique of Ref. 66 has been extended to three laser line heterodyning. Line no. 800 has been heterodyned with lines no. 513 and no. 710. Assuming that the frequencies reported in the tables for the two latter lines are correct, 2522.7824 (20) GHz are obtained for line no. 800. This value, although compatible with the preceding measurements, is in much better agreement with the result of tunable FIR spectroscopy.

[i] This line was due to the presence of $^{13}CH_3F$ impurities in the $^{13}CH_2F_2$ sample (see line no. 33).

TABLE II. Frequencies, wave numbers, wave lengths, CO_2 pumps, and lasing molecules of the FIR laser lines.

No.	Frequency (GHz)	Wave number (cm^{-1})	Wavelength (μm)	CO_2 pump	Molecule
1	144.8141	4.830 478	2070.188	10P(14)	CH_2F_2
2	147.5879	4.923 002	2031.281	10R(30)	$(H_2CO)_3$
3	150.5922	5.023 215	1990.757	9P(14)	$CD_3{}^{37}Cl$
4	152.5155	5.087 369	1965.652	10P(28)	$CH_3{}^{79}Br$
5	157.7947	5.263 465	1899.889	10P(20)	C_2H_3Br

TABLE II. Continued.

No.	Frequency (GHz)	Wave number (cm^{-1})	Wavelength (μm)	CO_2 pump	Molecule
6	158.8981	5.300 271	1886.696	9P(26)	CH_3Cl
7	164.0159	5.470 982	1827.826	10P(20)	ClO_2
8	173.2070	5.777 564	1730.833	10R(24)	HCOOD
9	174.8948	5.833 863	1714.130	9P(30)	CD_2F_2
10	185.6429	6.192 381	1614.888	10P(26)	C_2H_3Br
11	189.5375	6.322 290	1581.705	9P(26)	$(H_2CO)_3$
12	189.7537	6.329 502	1579.903	10R(12)	$(H_2CO)_3$
13	193.4763	6.453 675	1549.505	9R(10)	CD_3I
14	194.4494	6.486 134	1541.750	9P(30)	HCOOD
15	197.0535	6.572 997	1521.376	9P(10)	C_2H_5F
16	200.9539	6.703 101	1491.847	9P(14)	$H^{13}COOH$
17	207.0253	6.905 621	1448.096	9R(44)	CH_2F_2
18	215.0495	7.173 279	1394.063	10R(20)	C_2H_3Br
19	216.6315	7.226 049	1383.882	10P(24)	C_2H_3Br
20	228.7186	7.629 231	1310.748	10P(14)	ClO_2
21	228.7498	7.630 272	1310.569	10R(4)	$CH_3\,{}^{79}Br$
22	231.9041	7.735 488	1292.743	10R(10)	$(H_2CO)_3$
23	233.9116	7.802 451	1281.649	9P(38)	DCOOD
24	237.8247	7.932 978	1260.561	10R(16)	CDF_3
25	239.0958	7.975 377	1253.859	10P(32)	CH_3I
26	239.1028	7.975 611	1253.822	10P(32)	CH_3I
27	239.1042	7.975 658	1253.815	10P(32)	CH_3I
28	239.1192	7.976 158	1253.736	10P(32)	CH_3I
29	240.2965	8.015 428	1247.594	10R(12)	C_2H_3Br
30	241.8696	8.067 901	1239.480	9P(12)	$CD_3\,{}^{35}Cl$
31	242.1654	8.077 768	1237.966	10R(24)	DCOOH
32	244.9966	8.172 207	1223.660	9P(16)	CH_3OH
33	245.3507	8.184 018	1221.894	9P(32)	${}^{13}CH_3F$
34	245.3508	8.184 022	1221.893	9P(32)	${}^{13}CH_2F_2$
35	247.0758	8.241 562	1213.362	9P(28)	$H^{12}COOH$
36	252.9726	8.438 258	1185.079	10R(22)	$(H_2CO)_3$
37	258.0688	8.608 249	1161.676	10R(20)	HCOOD
38	259.0407	8.640 668	1157.318	10R(38)	HCOOD
39	264.3409	8.817 463	1134.113	10P(16)	ClO_2
40	265.8319	8.867 198	1127.752	10P(26)	C_2H_3CN
41	268.5148	8.956 690	1116.484	9R(30)	$H^{13}COOH$
42	272.6516	9.094 678	1099.544	10P(22)	CD_3I
43	274.6260	9.160 537	1091.639	9P(16)	CH_2F_2
44	277.4476	9.254 656	1080.537	10R(12)	CDF_3
45	280.1195	9.343 781	1070.231	9P(12)	DCOOD
46	283.6654	9.462 059	1056.852	10P(18)	CH_3Br
47	284.5744	9.492 380	1053.477	10R(22)	$(H_2CO)_3$
48	286.1766	9.545 824	1047.579	10R(12)	DCOOH
49	288.3021	9.616 723	1039.855	9P(24)	C_2H_3Cl
50	290.9538	9.705 174	1030.378	9R(30)	$H^{13}COOH$
51	291.9936	9.739 858	1026.709	10R(28)	C_2H_3Cl
52	292.0018	9.740 132	1026.680	10R(38)	C_2H_3Cl
53	294.4169	9.820 691	1018.258	10P(14)	CH_2F_2
54	295.0688	9.842 436	1016.009	10P(32)	C_2H_3CN
55	296.9979	9.906 784	1009.409	10R(18)	DCOOD
56	297.2486	9.915 146	1008.558	10R(12)	CDF_3
57	298.1978	9.946 808	1005.348	10P(34)	CD_3I
58	300.2386	10.014 882	998.514	9P(12)	DCOOD
59	302.6280	10.094 584	990.630	10R(4)	C_2H_3Br
60	302.6466	10.095 204	990.569	10P(10)	$CH_3\,{}^{81}Br$
61	303.0685	10.109 277	989.190	10P(16)	C_2H_3Br
62	303.2203	10.114 341	988.695	10R(28)	C_2H_3Cl
63	303.3540	10.118 800	988.259	10P(24)	C_2H_3Cl
64	303.9415	10.138 397	986.349	10P(28)	C_2H_3CN
65	303.9528	10.138 774	986.313	10R(32)	HCOOD
66	304.0275	10.141 266	986.070	10R(20)	CHD_2F
67	304.0927	10.143 441	985.859	10R(2)	C_2H_3Br
68	304.4211	10.154 395	984.795	10P(46)	CHD_2F
69	305.3780	10.186 314	981.709	10P(22)	CD_3I
70	308.4899	10.290 115	971.806	10R(28)	DCOOH
71	311.1535	10.378 964	963.487	10P(10)	C_2H_3Br
72	314.0943	10.477 058	954.466	10P(30)	CH_2F_2
73	314.2874	10.483 499	953.880	9R(28)	CD_3I
74	315.6757	10.529 808	949.685	10P(16)	ClO_2

TABLE II. Continued.

No.	Frequency (GHz)	Wave number (cm^{-1})	Wavelength (μm)	CO_2 pump	Molecule
75	315.9286	10.538 244	948.925	9R(24)	$(H_2CO)_3$
76	316.1534	10.545 742	948.250	10R(6)	$(H_2CO)_3$
77	317.5675	10.592 910	944.028	9R(12)	CH_3Cl
78	317.5703	10.593 005	944.019	9R(12)	CH_3Cl
79	318.4246	10.621 501	941.486	10R(18)	CD_3Br
80	320.0851	10.676 890	936.602	10P(26)	DCOOD
81	320.2367	10.681 947	936.159	10R(32)	C_2H_3Br
82	320.4268	10.688 288	935.604	9R(10)	$^{13}CH_2F_2$
83	320.6304	10.695 079	935.009	9P(16)	DCOOD
84	320.9003	10.704 082	934.223	9P(28)	C_2H_3Br
85	323.0587	10.776 078	927.981	10P(20)	DCOOD
86	323.6770	10.796 703	926.209	10R(14)	HCOOD
87	325.8842	10.870 327	919.936	10R(32)	HCOOD
88	326.3544	10.886 011	918.610	9R(28)	CD_3I
89	326.5187	10.891 491	918.148	10P(22)	CH_2F_2
90	326.6138	10.894 664	917.881	10P(22)	CH_2F_2
91	327.7208	10.931 589	914.780	9R(14)	ClO_2
92	327.7297	10.931 886	914.755	9R(14)	ClO_2
93	327.7368	10.932 123	914.735	9R(14)	ClO_2
94	331.1058	11.044 501	905.428	9R(4)	$CHCl_2F$
95	332.0738	11.076 790	902.789	9R(30)	$^{13}CH_2F_2$
96	332.6626	11.096 430	901.191	10R(12)	C_2H_3CN
97	333.0532	11.109 459	900.134	10R(18)	C_2H_3Br
98	333.3309	11.118 722	899.384	9R(38)	CF_2HCl
99	334.0229	11.141 805	897.521	9P(14)	$^{13}CH_2F_2$
100	335.3303	11.185 415	894.021	9R(16)	$^{13}CH_2F_2$
101	336.4344	11.222 244	891.087	10R(32)	$H^{13}COOH$
102	336.9529	11.239 539	889.716	9R(26)	$(H_2CO)_3$
103	337.0478	11.242 704	889.466	9R(20)	$(H_2CO)_3$
104	337.1919	11.247 511	889.086	10P(22)	CH_2F_2
105	337.2767	11.250 340	888.862	10P(22)	CH_2F_2
106	339.2860	11.317 363	883.598	9P(34)	CD_3Cl
107	341.6251	11.395 387	877.548	10P(26)	DCOOD
108	343.9624	11.473 351	871.585	9R(14)	CD_3OH
109	347.5680	11.593 621	862.543	10R(20)	CHD_2F
110	349.3051	11.651 564	858.254	10R(18)	CD_3OH
111	350.8048	11.701 589	854.585	9P(16)	CH_3CN
112	351.2762	11.717 313	853.438	10P(10)	C_2H_3Br
113	352.1484	11.746 406	851.324	10R(18)	CD_3Br
114	355.5258	11.859 064	843.237	9P(12)	DCOOD
115	355.7847	11.867 700	842.623	10P(30)	CH_2F_2
116	355.9952	11.874 722	842.125	9R(16)	CF_2HCl
117	357.5897	11.927 908	838.370	9P(12)	$H^{13}COOH$
118	359.9999	12.008 304	832.757	9R(4)	$CHCl_2F$
119	360.6451	12.029 826	831.267	10P(28)	$CH_3{}^{81}Br$
120	362.5304	12.092 712	826.944	10P(22)	C_2H_3Br
121	367.3051	12.251 979	816.195	10P(16)	C_2H_3CN
122	367.7880	12.268 087	815.123	9P(24)	C_2H_3Cl
123	368.4053	12.288 678	813.757	9P(12)	HCOOD
124	368.4522	12.290 242	813.654	9P(32)	$(H_2CO)_3$
125	379.5612	12.660 799	789.840	9R(36)	$H^{12}COOH$
126	379.7628	12.667 523	789.420	10R(20)	DCOOD
127	380.0040	12.675 569	788.919	9P(12)	$H^{13}COOH$
128	380.2149	12.682 604	788.482	10P(12)	CD_3I
129	380.9588	12.707 418	786.942	9R(32)	$H^{12}COOH$
130	381.3369	12.720 030	786.162	9R(40)	$H^{12}COOH$
131	382.2576	12.750 741	784.268	10P(24)	C_2H_3Br
132	384.2838	12.818 328	780.133	10P(14)	C_2H_3Br
133	384.4112	12.822 577	779.874	10P(26)	DCOOD
134	388.8169	12.969 536	771.038	10P(20)	$(H_2CO)_3$
135	389.8201	13.002 999	769.053	10R(44)	C_2H_3CN
136	390.3488	13.020 634	768.012	10R(26)	CHD_2F
137	393.5515	13.127 465	761.762	10P(10)	DCOOD
138	398.2638	13.284 650	752.748	10R(34)	DCOOH
139	398.2966	13.285 744	752.686	9R(32)	CD_2O
140	398.7497	13.300 858	751.831	10P(28)	C_2H_3CN
141	399.4006	13.322 570	750.606	10P(20)	$(H_2CO)_3$
142	400.0487	13.344 188	749.390	10R(14)	$CH_3{}^{79}Br$
143	400.0584	13.344 512	749.372	9P(30)	$(H_2CO)_3$
144	400.0587	13.344 522	749.371	10P(14)	$CH_3{}^{79}Br$

TABLE II. Continued.

No.	Frequency (GHz)	Wave number (cm^{-1})	Wavelength (μm)	CO_2 pump	Molecule
145	400.0603	13.344 575	749.368	10R(14)	CH_3Br
146	401.3017	13.385 984	747.050	9R(10)	CF_2HCl
147	402.9196	13.439 951	744.050	9R(24)	$H^{12}COOH$
148	403.7217	13.466 706	742.572	9R(40)	$H^{12}COOH$
149	404.5155	13.493 185	741.115	10P(20)	C_2H_3Br
150	405.9951	13.542 539	738.414	9R(12)	$^{13}CH_2F_2$
151	406.7117	13.566 442	737.113	10R(32)	CD_2O
152	407.4264	13.590 282	735.820	10R(12)	CH_3Br
153	407.8089	13.603 041	735.130	9P(6)	$CD_3{}^{37}Cl$
154	407.9038	13.606 206	734.959	9P(36)	$^{13}CH_2F_2$
155	408.2906	13.619 108	734.262	9P(22)	CD_3I
156	408.3467	13.620 980	734.162	10R(38)	N_2H_4
157	408.6611	13.631 467	733.597	9P(32)	CD_2O
158	408.6738	13.631 891	733.574	9P(32)	CD_2O
159	410.4927	13.692 563	730.323	9R(28)	CD_3I
160	411.8316	13.737 224	727.949	10R(42)	HCOOD
161	412.0463	13.744 385	727.570	10P(16)	C_2H_3CN
162	412.4145	13.756 667	726.920	10P(10)	DCOOD
163	413.5523	13.794 620	724.920	9P(4)	CH_2F_2
164	413.9980	13.809 487	724.140	10P(14)	C_2H_3Br
165	415.0184	13.843 524	722.359	9P(10)	$^{18}O_3$
166	419.0617	13.978 394	715.390	10R(14)	$CH_3{}^{79}Br$
167	420.4040	14.023 168	713.106	10R(34)	DCOOH
168	421.2037	14.049 843	711.752	9R(32)	$(H_2CO)_3$
169	423.9021	14.139 852	707.221	10R(24)	C_2H_3Br
170	425.2827	14.185 904	704.925	9P(18)	C_2H_3Cl
171	428.6285	14.297 508	699.423	9P(34)	CH_3OH
172	429.1607	14.315 260	698.555	9P(6)	$CD_3{}^{37}Cl$
173	429.8376	14.337 839	697.455	10R(36)	DCOOH
174	430.9394	14.374 591	695.672	10R(36)	HCOOD
175	431.1390	14.381 249	695.350	10R(16)	CH_3OH
176	431.2307	14.384 308	695.202	9P(22)	C_2H_3Cl
177	431.7114	14.400 342	694.428	9R(16)	$(H_2CO)_3$
178	431.8598	14.405 292	694.189	9P(24)	CH_3OH
179	432.5138	14.427 107	693.140	10R(16)	C_2H_3Br
180	433.2106	14.450 350	692.025	9P(26)	$CD_3{}^{79}Br$
181	433.6958	14.466 535	691.251	10R(26)	CHD_2F
182	433.7782	14.469 283	691.119	9R(20)	CD_3I
183	434.4830	14.492 793	689.998	10R(26)	HCOOD
184	435.0000	14.510 038	689.178	9R(22)	$^{13}CH_2F_2$
185	435.8481	14.538 328	687.837	10R(10)	CDF_3
186	438.4607	14.625 475	683.738	10R(20)	C_2H_3Cl
187	439.4656	14.658 995	682.175	10P(14)	CF_2HCl
188	440.5205	14.694 182	680.541	10R(16)	C_2H_3Br
189	441.0232	14.710 950	679.766	10P(34)	$(H_2CO)_3$
190	442.1967	14.750 094	677.962	9P(12)	CH_2F_2
191	444.7554	14.835 443	674.061	9P(4)	$^{13}CH_2F_2$
192	447.3751	14.922 827	670.114	10R(8)	CD_3I
193	447.3887	14.923 281	670.094	10R(8)	CD_3I
194	447.7650	14.935 833	669.531	9R(30)	$H^{12}COOH$
195	449.3075	14.987 285	667.232	10P(10)	CD_3I
196	449.7310	15.001 411	666.604	10R(20)	C_2H_3Cl
197	450.2164	15.017 603	665.885	10P(18)	CF_2HCl
198	452.3015	15.087 154	662.816	10P(24)	CH_2F_2
199	453.4389	15.125 094	661.153	9R(30)	$CHCl_2F$
200	453.6246	15.131 288	660.882	10R(20)	$^{13}CH_3{}^{79}Br$
201	453.8306	15.138 159	660.582	10P(46)	CD_3I
202	455.5062	15.194 051	658.152	10P(6)	CDF_3
203	455.6191	15.197 817	657.989	10R(10)	CDF_3
204	455.6547	15.199 005	657.938	10P(12)	CDF_3
205	456.1391	15.215 163	657.239	9P(10)	CH_2F_2
206	461.5862	15.396 858	649.483	9P(20)	C_2H_3Cl
207	461.6272	15.398 226	649.425	10P(18)	C_2H_3Br
208	463.1083	15.447 630	647.348	10R(30)	DCOOH
209	463.7324	15.468 448	646.477	10R(8)	CD_3OH
210	465.8664	15.539 630	643.516	9P(22)	CD_2F_2
211	466.5305	15.561 782	642.600	10R(44)	CH_2F_2
212	469.0647	15.646 314	639.128	10P(8)	DCOOH
213	469.6041	15.664 307	638.394	9P(26)	$^{13}CH_2F_2$
214	471.8505	15.739 239	635.355	10R(26)	C_2H_3Br

TABLE II. Continued.

No.	Frequency (GHz)	Wave number (cm^{-1})	Wavelength (μm)	CO_2 pump	Molecule
215	472.5077	15.761 160	634.471	9P(20)	C_2H_3Cl
216	474.3180	15.821 545	632.050	10P(22)	$CH_3{}^{79}Br$
217	475.7356	15.868 831	630.166	10R(10)	HCOOD
218	475.9787	15.876 940	629.844	9P(12)	$^{13}CH_3OH$
219	480.1057	16.014 602	624.430	9P(38)	CH_3OH
220	480.3629	16.023 182	624.096	10R(18)	C_2H_3Br
221	484.3987	16.157 801	618.896	9R(8)	$^{13}CH_2F_2$
222	484.7511	16.169 556	618.446	10R(30)	C_2H_3Br
223	485.3713	16.190 244	617.656	9P(28)	CF_2HCl
224	486.4115	16.224 941	616.335	9P(26)	CH_2DOH
225	487.2066	16.251 463	615.329	10R(14)	CF_2HCl
226	488.0347	16.279 085	614.285	9P(24)	CH_3OH
227	488.1740	16.283 732	614.110	10R(22)	CD_3I
228	493.3118	16.455 110	607.714	10P(36)	$(H_2CO)_3$
229	497.5916	16.597 869	602.487	9P(24)	CH_3OH
230	498.0791	16.614 130	601.897	10P(38)	CH_2CHCl
231	500.0292	16.679 179	599.550	10R(22)	CD_3I
232	504.0828	16.814 392	594.729	10P(32)	C_2H_3Br
233	505.1214	16.849 036	593.506	9P(36)	CH_3CH_2F
234	505.3141	16.855 464	593.279	9P(30)	CD_2F_2
235	505.7584	16.870 284	592.758	9R(16)	CH_2F_2
236	506.0294	16.879 324	592.441	9R(40)	CF_2HCl
237	506.7351	16.902 864	591.616	10R(26)	DCOOD
238	506.8851	16.907 867	591.441	10P(26)	CH_2F_2
239	507.1214	16.915 749	591.165	9P(14)	CH_2F_2
240	507.1511	16.916 740	591.130	10R(24)	CF_2HCl
241	507.8048	16.938 545	590.369	9P(18)	C_2H_3Cl
242	508.7082	16.968 679	589.321	9P(30)	CH_3CN
243	509.8272	17.006 005	588.028	9R(46)	CH_2F_2
244	509.9513	17.010 144	587.884	9P(16)	CH_2F_2
245	511.2581	17.053 735	586.382	10P(20)	C_2H_3CN
246	511.7858	17.071 337	585.777	9P(40)	$CH_3{}^{81}Br$
247	513.4555	17.127 032	583.872	10P(12)	C_2H_3CN
248	514.6178	17.165 802	582.554	9P(18)	HCOOD
249	515.1211	17.182 590	581.984	10R(28)	CDF_3
250	516.1102	17.215 583	580.869	9R(12)	$CHCl_2F$
251	516.1707	17.217 601	580.801	9P(38)	$H^{12}COOH$
252	516.5387	17.229 876	580.387	9R(22)	$H^{12}COOH$
253	517.0965	17.248 483	579.761	10P(16)	C_2H_3Cl
254	522.2622	17.420 792	574.027	10R(16)	C_2H_3CN
255	523.4797	17.461 403	572.692	10R(20)	C_2H_3CN
256	523.8104	17.472 434	572.330	9R(32)	$H^{13}COOH$
257	525.4275	17.526 375	570.569	9P(16)	CH_3OH
258	525.6453	17.533 640	570.332	9R(20)	$^{13}CH_2F_2$
259	526.4344	17.559 961	569.477	10P(36)	CD_3I
260	527.8541	17.607 318	567.946	10P(16)	C_2H_3Cl
261	527.9260	17.609 716	567.868	10R(26)	DCOOD
262	528.2392	17.620 163	567.532	9R(28)	CH_2F_2
263	528.6352	17.633 372	567.106	10P(14)	HCOOD
264	533.0118	17.779 360	562.450	9R(34)	CF_2HCl
265	534.1096	17.815 979	561.294	10P(20)	DCOOD
266	534.3628	17.824 424	561.028	9R(40)	$CHCl_2F$
267	534.5774	17.831 583	560.803	10R(40)	CDF_3
268	534.6727	17.834 762	560.703	10R(36)	CDF_3
269	536.7073	17.902 628	558.577	9R(10)	$(H_2CO)_3$
270	538.3473	17.957 333	556.876	10P(36)	CD_3I
271	538.4178	17.959 685	556.803	9R(30)	$CD_3{}^{81}Br$
272	539.1013	17.982 484	556.097	9R(34)	CF_2HCl
273	540.7851	18.038 649	554.365	10P(14)	CH_2F_2
274	541.2562	18.054 363	553.883	9P(32)	$CD_3{}^{79}Br$
275	541.4385	18.060 444	553.696	10P(40)	C_2H_3Br
276	545.3882	18.192 192	549.686	10P(14)	C_2H_3CN
277	545.8132	18.206 369	549.258	9R(8)	$CHCl_2F$
278	546.2253	18.220 115	548.844	9P(20)	$H^{13}COOH$
279	547.5376	18.263 888	547.529	9R(10)	$CHCl_2F$
280	549.6628	18.334 777	545.412	10R(32)	$CH_3{}^{81}Br$
281	549.7960	18.339 222	545.279	10P(38)	$CH_3{}^{81}Br$
282	554.1590	18.484 755	540.986	9R(42)	CH_2F_2
283	554.4156	18.493 314	540.736	10R(36)	CDF_3

TABLE II. Continued.

No.	Frequency (GHz)	Wave number (cm^{-1})	Wavelength (μm)	CO_2 pump	Molecule
284	559.2141	18.653 375	536.096	9P(24)	$H^{13}COOH$
285	560.9570	18.711 511	534.430	9R(34)	CH_2HCl
286	561.7240	18.737 096	533.701	9R(28)	$H^{12}COOH$
287	561.7475	18.737 880	533.678	9P(16)	$H^{12}COOH$
288	561.7720	18.738 697	533.655	10R(8)	N_2H_4
289	561.8586	18.741 586	533.573	9R(6)	CH_2F_2
290	562.3174	18.756 889	533.137	10R(16)	CF_2HCl
291	564.1953	18.819 529	531.363	9P(8)	$^{13}CH_2F_2$
292	564.2953	18.822 865	531.269	9P(8)	$^{13}CH_2F_2$
293	564.5407	18.831 051	531.038	10R(18)	$CH_3{}^{81}Br$
294	564.7361	18.837 569	530.854	9R(6)	$CHCl_2F$
295	565.0778	18.848 967	530.533	9P(16)	C_2H_3Cl
296	565.5051	18.863 220	530.132	10R(10)	$CD_3{}^{79}Br$
297	565.7742	18.872 196	529.880	9R(4)	CD_3CN
298	566.8436	18.907 867	528.880	9P(18)	CH_2F_2
299	567.2553	18.921 600	528.497	10R(40)	C_2H_3Br
300	567.9254	18.943 952	527.873	9P(12)	N_2H_4
301	568.6346	18.967 609	527.215	10P(34)	DCOOD
302	569.4219	18.993 870	526.486	10P(34)	DCOOD
303	572.7721	19.105 621	523.406	10P(38)	CD_3I
304	573.1168	19.117 119	523.091	9P(40)	CH_2DOH
305	575.1561	19.185 142	521.237	10R(24)	CDF_3
306	577.2975	19.256 572	519.303	9P(36)	CD_3Cl
307	577.5511	19.265 031	519.075	9R(4)	CH_3CH_2F
308	580.7082	19.370 341	516.253	9P(30)	CD_3CN
309	581.9297	19.411 085	515.170	9P(16)	$H^{12}COOH$
310	582.1770	19.419 334	514.951	10P(34)	DCOOD
311	584.3729	19.492 582	513.016	9R(28)	$H^{12}COOH$
312	584.3882	19.493 092	513.002	9R(28)	$H^{12}COOH$
313	586.1674	19.552 440	511.445	9R(28)	CH_2F_2
314	587.9556	19.612 088	509.890	10P(40)	$(H_2CO)_3$
315	587.9911	19.613 272	509.859	9R(36)	ClO_2
316	588.5534	19.632 028	509.372	10P(46)	CH_2DOH
317	589.2250	19.654 430	508.791	10P(8)	DCOOD
318	590.6184	19.700 909	507.591	10P(22)	C_2H_3Cl
319	590.6263	19.701 173	507.584	10P(22)	C_2H_3Cl
320	593.9401	19.811 709	504.752	10R(38)	CDF_3
321	595.9417	19.878 475	503.057	9R(6)	CH_2F_2
322	596.8842	19.909 914	502.262	9R(24)	CH_3CH_2F
323	598.1924	19.953 551	501.164	10P(18)	$(H_2CO)_3$
324	598.8937	19.976 944	500.577	10R(24)	CD_2F_2
325	602.3839	20.093 364	497.677	9P(28)	CD_2F_2
326	603.6172	20.134 503	496.660	9P(14)	$^{13}CH_2F_2$
327	604.2369	20.155 173	496.151	9P(20)	CH_3F
328	604.2973	20.157 188	496.101	9P(20)	CH_3F
329	604.3347	20.158 436	496.070	9P(20)	CH_3F
330	604.4650	20.162 782	495.963	9P(8)	$CHCl_2F$
331	606.0747	20.216 476	494.646	9P(6)	CH_3CN
332	607.4312	20.261 724	493.541	10R(4)	CH_3OH
333	607.9057	20.277 551	493.156	10R(40)	HCOOD
334	609.2846	20.323 547	492.040	9R(36)	$CHCl_2F$
335	609.4698	20.329 724	491.891	10P(8)	DCOOD
336	610.1083	20.351 022	491.376	10P(30)	$(H_2CO)_3$
337	611.3336	20.381 884	480.381	8R(22)	CD_3I
338	611.7178	20.404 709	490.083	10P(16)	C_2H_3Br
339	612.7748	20.439 967	489.238	10R(26)	CD_2F_2
340	613.0250	20.448 313	489.038	9R(32)	$^{18}O_3$
341	613.6653	20.469 671	488.528	10R(38)	CDF_3
342	613.9815	20.480 218	488.276	9P(42)	CD_2F_2
343	615.3046	20.524 352	487.226	9P(10)	CD_3I
344	615.4085	20.527 818	487.144	9R(32)	CF_2HCl
345	615.8833	20.543 656	486.768	10P(22)	CH_2F_2
346	618.4175	20.628 187	484.774	10R(28)	CH_2F_2
347	620.7378	20.705 584	482.961	10P(26)	C_2H_3Br
348	622.6836	20.770 489	481.452	9R(30)	CF_2HCl
349	624.1643	20.819 880	480.310	9P(36)	CD_3Cl
350	624.6926	20.837 502	479.904	10P(14)	DCOOH
351	625.7115	20.871 489	479.122	9R(40)	$^{13}CH_2F_2$
352	627.2291	20.922 111	477.963	9P(30)	$H^{13}COOH$

TABLE II. Continued.

No.	Frequency (GHz)	Wave number (cm^{-1})	Wavelength (μm)	CO_2 pump	Molecule
353	637.3326	21.259 127	470.386	9R(34)	$CHCl_2F$
354	639.1846	21.320 903	469.023	10R(38)	CH_3OH
355	639.2646	21.323 572	468.965	10R(26)	$^{13}CD_3OH$
356	640.2595	21.356 758	468.236	9P(26)	CH_2DOH
357	641.2469	21.389 694	467.515	9R(6)	$CHCl_2F$
358	642.4451	21.429 662	466.643	10R(26)	CD_3Br
359	642.5784	21.434 108	466.546	10P(14)	DCOOH
360	645.0524	21.516 632	464.757	10R(20)	$CD_3{}^{35}Cl$
361	645.2318	21.522 616	464.628	9R(26)	$H^{13}COOH$
362	645.5309	21.532 593	464.412	9P(6)	CH_2F_2
363	646.6281	21.569 192	463.624	10R(20)	CH_2CF_2
364	649.7667	21.673 884	461.385	9P(12)	$^{13}CH_3OH$
365	649.9410	21.679 698	461.261	10P(16)	HCOOD
366	650.2077	21.688 594	461.072	10P(16)	N_2H_4
367	650.9275	21.712 604	460.562	9R(12)	CD_3I
368	651.8845	21.744 526	459.886	10R(24)	ClO_2
369	652.5339	21.766 188	459.428	9R(22)	$(H_2CO)_3$
370	653.6245	21.802 566	458.662	10R(20)	CH_3Br
371	653.8214	21.809 134	458.523	9R(38)	HCOOH
372	653.8222	21.809 161	458.523	9R(38)	$H^{12}COOH$
373	655.5119	21.865 523	457.341	10P(30)	DCOOD
374	658.7786	21.974 489	455.073	9P(8)	CD_3CN
375	661.2134	22.055 705	453.397	9R(16)	CH_3CN
376	662.6350	22.103 124	452.425	9P(16)	$^{13}CH_2F_2$
377	664.0284	22.149 603	451.475	9P(32)	CH_2DOH
378	664.7579	22.173 937	450.980	10P(12)	HCOOD
379	666.5020	22.232 114	449.800	10R(20)	$CD_3{}^{35}Cl$
380	668.3836	22.294 877	448.534	9R(26)	$H^{13}COOH$
381	668.5001	22.298 763	448.455	9P(12)	CH_3OH
382	670.4630	22.364 238	447.142	10P(18)	CH_3I
383	670.8672	22.377 721	446.873	9R(16)	$H^{12}COOH$
384	671.4195	22.396 144	446.505	9R(22)	$H^{12}COOH$
385	672.3318	22.426 575	445.900	9R(20)	$H^{12}COOH$
386	672.6895	22.438 506	445.662	10P(20)	CDF_3
387	674.6213	22.502 944	444.386	9R(32)	CD_3I
388	676.3285	22.559 890	443.265	9P(10)	$CD_3{}^{35}Cl$
389	678.0061	22.615 849	442.168	10P(16)	CH_2CHCl
390	678.7644	22.641 143	441.674	9R(16)	CD_3Br
391	679.9798	22.681 685	440.884	10P(32)	CD_2F_2
392	682.8004	22.775 770	439.063	9R(18)	CH_2F_2
393	683.6665	22.804 660	438.507	10P(28)	C_2H_3Br
394	684.4233	22.829 904	438.022	10R(18)	$^{13}CH_2F_2$
395	685.3166	22.859 701	437.451	9P(16)	$H^{12}COOH$
396	687.9574	22.947 789	435.772	10P(24)	N_2H_4
397	688.5030	22.965 988	435.427	10R(38)	CHD_2F
398	689.2551	22.991 075	434.951	9R(6)	CH_2F_2
399	691.6624	23.071 374	433.438	10R(34)	CF_2HCl
400	691.9853	23.082 145	433.235	10R(14)	DCOOH
401	692.1955	23.089 157	433.104	9P(28)	CD_3I
402	692.3815	23.095 361	432.987	10P(20)	CDF_3
403	692.8950	23.112 489	432.667	9R(20)	$H^{12}COOH$
404	692.9514	23.114 371	432.631	9R(20)	$H^{12}COOH$
405	693.5729	23.135 102	432.244	9R(40)	CF_2HCl
406	693.7884	23.142 290	432.109	9R(22)	$H^{12}COOH$
407	694.3884	23.162 304	431.736	9P(18)	$CD_3{}^{79}Br$
408	695.6915	23.205 771	430.927	10R(34)	CD_3OH
409	696.4109	23.229 767	430.482	10P(18)	CH_3CN
410	696.4823	23.232 149	430.438	10P(6)	HCOOD
411	697.6951	23.272 603	429.690	10P(24)	HCOOD
412	700.7662	23.375 044	427.807	9R(26)	CF_2HCl
413	708.1371	23.620 911	423.354	10R(30)	C_2H_3Cl
414	710.1543	23.688 198	422.151	9R(8)	CH_2DOH
415	710.2123	23.690 132	422.117	10P(24)	CH_3CN
416	712.0058	23.749 957	421.053	9P(14)	$^{13}CH_2F_2$
417	712.1306	23.754 120	420.980	10R(46)	CDF_3
418	713.1276	23.787 376	420.391	9R(8)	$H^{12}COOH$
419	713.2631	23.791 896	420.311	10R(26)	CDF_3
420	714.0658	23.818 671	419.839	10P(22)	$(H_2CO)_3$
421	715.9876	23.882 776	418.712	10R(36)	CD_3OH

TABLE II. Continued.

No.	Frequency (GHz)	Wave number (cm^{-1})	Wavelength (μm)	CO_2 pump	Molecule
422	716.1568	23.888 420	418.613	9R(22)	$H^{12}COOH$
423	716.7433	23.907 983	418.270	9R(12)	CH_2F_2
424	717.0650	23.918 714	418.083	9P(36)	CH_3OH
425	718.5056	23.966 767	417.244	9P(20)	CD_2F_2
426	719.7512	24.008 316	416.522	9P(14)	CH_3OH
427	721.7598	24.075 315	415.363	9P(4)	$^{13}CH_2F_2$
428	722.2605	24.092 017	415.075	9R(30)	CF_2HCl
429	723.5229	24.134 126	414.351	9R(36)	CF_2HCl
430	729.9328	24.347 937	410.712	10R(12)	CD_3OD
431	736.0596	24.552 305	407.294	10P(14)	CH_2F_2
432	736.8120	24.577 403	406.878	10P(28)	CHD_2F
433	739.1610	24.655 757	405.585	9R(18)	$H^{12}COOH$
434	739.3075	24.660 644	405.504	9R(30)	CH_3CH_2F
435	739.3403	24.661 738	405.486	9P(16)	CHDO
436	742.4704	24.766 147	403.777	9P(32)	$^{13}CH_2F_2$
437	742.5939	24.770 266	403.710	9P(4)	CH_2F_2
438	746.7847	24.910 056	401.444	9P(38)	CH_2F_2
439	750.8176	25.044 579	399.288	9R(34)	$^{13}CH_2F_2$
440	757.6019	25.270 879	395.712	10R(12)	HCOOD
441	758.6825	25.306 924	395.149	10R(10)	DCOOD
442	759.5433	25.335 637	394.701	9P(6)	CH_2F_2
443	761.6083	25.404 518	393.631	9R(18)	$H^{12}COOH$
444	761.8888	25.413 875	393.486	9P(32)	$H^{13}COOH$
445	764.6426	25.505 732	392.069	9P(36)	CH_3OH
446	765.3846	25.530 482	391.689	10R(38)	HCOOD
447	765.8290	25.545 306	391.461	9R(30)	$^{13}CH_2F_2$
448	768.8820	25.647 143	389.907	10R(12)	DCOOD
449	771.3654	25.729 980	388.652	10R(42)	CDF_3
450	772.1170	25.755 051	388.273	10R(32)	CDF_3
451	772.5420	25.769 227	388.060	9P(32)	C_2H_5OH
452	773.5399	25.802 514	387.559	9P(40)	CH_2DOH
453	774.7261	25.842 081	386.966	9R(18)	CF_2HCl
454	775.9824	25.883 987	386.339	9P(14)	CH_3OH
455	776.5891	25.904 224	386.037	10R(34)	CD_3OH
456	776.8471	25.912 830	385.909	10P(22)	CH_2CHCl
457	777.2948	25.927 764	385.687	9R(18)	CF_2HCl
458	778.9467	25.982 865	384.869	9R(30)	$(H_2CO)_3$
459	780.0615	26.020 051	384.319	10P(28)	CHD_2F
460	782.1667	26.090 273	383.285	9R(34)	$CD_3{}^{35}Cl$
461	783.2267	26.125 631	382.766	10R(40)	CF_2HCl
462	783.4860	26.134 280	382.639	9P(10)	CH_2F_2
463	784.0631	26.153 530	382.358	9P(26)	$H^{13}COOH$
464	784.8060	26.178 310	381.996	9R(36)	CH_2F_2
465	785.5872	26.204 368	381.616	9P(24)	$H^{13}COOH$
466	787.7555	26.276 695	380.565	10R(12)	DCOOD
467	791.2604	26.393 606	378.880	10P(22)	CD_2F_2
468	793.6931	26.474 752	377.718	9R(10)	$^{13}CH_2F_2$
469	797.3625	26.597 150	375.980	9P(16)	$CHCl_2F$
470	798.2866	26.627 975	375.545	10P(12)	CH_2F_2
471	798.5795	26.637 745	375.407	9R(6)	CHD_2F
472	801.3996	26.731 813	374.086	10P(46)	CH_2DOH
473	804.0129	26.818 984	372.870	9R(22)	CF_2HCl
474	804.1348	26.823 050	372.814	10P(20)	CH_3CN
475	810.3205	27.029 382	369.968	10R(28)	HCOOD
476	812.1954	27.091 922	369.114	9P(16)	CH_3OH
477	812.7500	27.110 422	368.862	9R(18)	N_2H_4
478	815.9859	27.218 360	367.399	10R(14)	CD_2F_2
479	817.7083	27.275 813	366.625	9P(14)	$CD_3{}^{79}Br$
480	818.4946	27.302 041	366.273	9R(30)	CF_2HCl
481	819.4058	27.332 435	365.866	9R(34)	CD_2F_2
482	819.7205	27.342 933	365.725	9P(18)	$CHCl_2F$
483	822.5122	27.436 054	364.484	10P(28)	CD_2O
484	827.1884	27.592 035	362.423	9R(24)	CDF_3
485	829.9183	27.683 095	361.231	10P(24)	CDF_3
486	831.3569	27.731 081	360.606	9R(14)	CF_2HCl
487	831.5927	27.738 947	360.504	9P(16)	$^{13}CH_2F_2$
488	832.6350	27.773 714	360.053	9R(8)	CH_2F_2
489	834.2359	27.827 114	359.362	9R(22)	$^{13}CH_2F_2$
490	837.6408	27.940 690	357.901	9R(14)	CH_2F_2

TABLE II. Continued.

No.	Frequency (GHz)	Wave number (cm^{-1})	Wavelength (μm)	CO_2 pump	Molecule
491	837.7194	27.943 311	357.867	9R(20)	$^{13}CH_2F_2$
492	844.1859	28.159 011	355.126	9P(8)	CH_2F_2
493	844.1860	28.159 014	355.126	9P(8)	$^{13}CH_2F_2$
494	846.4503	28.234 543	354.176	10R(16)	CD_3OD
495	849.5064	28.336 483	352.902	10R(34)	CD_2F_2
496	856.7037	28.576 559	349.937	10R(20)	CH_3NH_2
497	858.0533	28.621 576	349.387	10R(18)	CH_3Cl
498	865.2331	28.861 070	346.488	9P(22)	CH_3OH
499	869.5227	29.004 155	344.778	10R(4)	CD_3OD
500	870.1719	29.025 810	344.521	9R(16)	$^{13}CH_2F_2$
501	876.2613	29.228 931	342.127	9P(44)	CD_2F_2
502	880.1204	29.357 656	340.627	10P(16)	$^{13}CD_3OH$
503	880.8186	29.380 946	340.357	10R(32)	CH_2DOH
504	880.9656	29.385 849	340.300	9P(20)	$CHCl_2F$
505	884.4381	29.501 679	338.964	9P(22)	$^{13}CH_3OH$
506	887.5511	29.605 518	337.775	9R(10)	CH_2F_2
507	889.3435	29.665 306	337.094	9R(32)	CF_2HCl
508	891.5863	29.740 118	336.246	9P(36)	CH_2DOH
509	893.0136	29.787 727	335.709	9R(8)	DCOOD
510	893.6569	29.809 186	335.467	9R(16)	CF_2HCl
511	897.7581	29.945 988	333.935	9P(42)	CH_3Cl
512	897.7819	29.946 781	333.926	9P(36)	$^{13}CH_2F_2$
513	899.5717	30.006 482	333.261	10P(16)	$^{13}CD_3OH$
514	901.3512	30.065 840	332.603	10R(16)	$^{13}CH_3OH$
515	903.8894	30.150 505	331.669	9P(12)	N_2H_4
516	905.4770	30.203 462	331.088	10P(30)	CHDO
517	905.7426	30.212 321	330.991	9P(34)	CD_2F_2
518	908.4086	30.301 249	330.019	10R(8)	CDF_3
519	911.3327	30.398 787	328.960	9R(28)	CF_2HCl
520	912.7297	30.445 386	328.457	10P(22)	DCOOH
521	918.4170	30.635 094	326.423	9R(14)	CH_2F_2
522	924.0784	30.823 938	324.423	10P(24)	CD_2O
523	924.8858	30.850 870	324.140	10R(14)	$^{13}CD_3OD$
524	927.6368	30.942 633	323.179	9P(40)	CD_2F_2
525	929.7268	31.012 348	322.452	9P(12)	CH_2DOH
526	932.7413	31.112 901	321.410	10R(12)	$^{13}CD_3OD$
527	935.1075	31.191 829	320.597	10R(44)	CD_2F_2
528	939.0003	31.321 679	319.268	9P(32)	CD_2O
529	942.5074	31.438 663	318.080	9R(12)	$^{13}CH_2F_2$
530	945.5625	31.540 570	317.052	9P(40)	CD_2F_2
531	947.7237	31.612 660	316.329	9R(24)	$^{13}CH_2F_2$
532	952.1850	31.761 473	314.847	9R(4)	CH_3NH_2
533	952.2039	31.762 103	314.841	10R(10)	CD_3OD
534	952.7933	31.781 764	314.646	9R(10)	CD_2F_2
535	955.3681	31.867 650	313.798	9P(6)	$H^{13}COOH$
536	955.3703	31.867 723	313.797	9P(6)	$H^{13}COOH$
537	960.0245	32.022 970	312.276	9P(24)	$^{13}CH_2F_2$
538	962.2500	32.097 205	311.554	10R(22)	HCOOH
539	963.3022	32.132 303	311.213	9R(8)	$^{13}CH_2F_2$
540	963.7314	32.146 619	311.075	9P(20)	N_2H_4
541	969.5968	32.342 268	309.193	9R(22)	CH_2F_2
542	972.4187	32.436 396	308.296	10R(34)	CH_2DOH
543	973.2243	32.463 268	308.040	9P(14)	CH_2DOH
544	976.5437	32.573 992	306.993	9R(40)	$^{13}CH_2F_2$
545	979.5445	32.674 087	306.053	9R(24)	CF_2HCl
546	980.5916	32.709 015	305.726	9R(8)	CH_3OD
547	985.8897	32.885 741	304.083	10R(24)	DCOOD
548	991.7778	33.082 146	302.278	9R(4)	$H^{12}COOH$
549	992.7089	33.113 205	301.994	9P(14)	CH_3OH
550	993.8299	33.150 597	301.654	10R(4)	$^{13}CH_2F_2$
551	995.0778	33.192 223	301.275	10R(12)	N_2H_4
552	997.7253	33.280 534	300.476	9P(18)	CH_2F_2
553	998.4879	33.305 971	300.246	10R(38)	$^{13}CH_2F_2$
554	998.5321	33.307 446	300.233	9R(36)	$^{13}CH_2F_2$
555	1003.5366	33.474 378	298.736	10R(24)	CD_3OD
556	1004.4306	33.504 198	298.470	9R(36)	CH_2F_2
557	1005.3033	33.533 309	298.211	9R(36)	CH_2F_2
558	1005.8500	33.551 545	298.049	9R(24)	CF_2HCl
559	1014.0477	33.824 990	295.639	10R(34)	CH_2DOH

TABLE II. Continued.

No.	Frequency (GHz)	Wave number (cm^{-1})	Wavelength (μm)	CO_2 pump	Molecule
560	1014.8810	33.852 786	295.397	9P(10)	CH_2DOH
561	1016.8972	33.920 039	294.811	9R(8)	CH_3OD
562	1020.0440	34.025 005	293.901	9P(20)	CH_2F_2
563	1020.3211	34.034 248	293.822	10R(10)	CH_3OH
564	1020.9247	34.054 382	293.648	9P(24)	$CD_3{}^{37}Cl$
565	1026.1893	34.229.991	292.141	9P(38)	CH_3OH
566	1030.8799	34.386 452	290.812	9R(24)	CH_2F_2
567	1031.3844	34.403 280	290.670	10R(14)	CD_3OD
568	1035.5527	34.542 320	289.500	9P(4)	CH_2F_2
569	1036.8448	34.585 420	289.139	9P(24)	CH_2F_2
570	1041.2794	34.733 342	287.908	9R(26)	CH_2F_2
571	1042.1504	34.762 396	287.667	9R(34)	CH_2F_2
572	1043.4545	34.805 896	287.308	10P(18)	CD_3OH
573	1045.5780	34.876 728	286.724	10P(24)	CD_3OH
574	1046.7682	34.916 429	286.398	9P(8)	CD_2F_2
575	1047.5023	34.940 916	286.197	9P(40)	CD_3OH
576	1047.6576	34.946 096	286.155	10R(48)	CH_3OH
577	1054.2918	35.167 389	284.354	9R(18)	CH_2F_2
578	1056.4147	35.238 201	283.783	9R(40)	CH_2F_2
579	1066.6754	35.580 461	281.053	9P(14)	CH_2F_2
580	1067.1272	35.595 532	280.934	9R(18)	CH_3OH
581	1068.7337	35.649 119	280.512	9P(30)	CD_2F_2
582	1069.7714	35.683 733	280.240	10R(16)	$^{13}CH_3OH$
583	1069.8534	35.686 468	280.218	10R(16)	$^{13}CH_3OH$
584	1074.4710	35.840 495	279.014	9P(22)	$^{13}CH_2F_2$
585	1075.2771	35.867 383	278.805	9P(38)	CH_3OH
586	1076.8428	35.919 609	278.399	10P(8)	CD_2O
587	1083.3951	36.138 171	276.716	10P(28)	CD_3OH
588	1091.0447	36.393 334	274.776	10R(26)	CD_2F_2
589	1093.1547	36.463 716	274.245	10R(46)	CH_3OH
590	1095.0770	36.527 837	273.764	9P(26)	$^{13}CH_2F_2$
591	1098.1259	36.629 537	273.004	9P(6)	CH_2DOH
592	1100.8067	36.718 959	272.339	9P(10)	CH_2F_2
593	1101.1594	36.730 724	272.252	9R(24)	CH_2DOH
594	1107.3379	36.936 816	270.733	9R(8)	CD_3OD
595	1110.3199	37.036 285	270.005	9R(22)	CH_2F_2
596	1116.2455	37.233 942	268.572	10R(16)	$^{13}CH_3OH$
597	1118.3692	37.304 781	268.062	9R(26)	CH_2F_2
598	1119.3680	37.338 097	267.823	9P(18)	CD_2F_2
599	1120.9576	37.391 121	267.443	10R(34)	CH_3OH
600	1123.3820	37.471 990	266.866	9R(24)	$^{13}CH_2F_2$
601	1123.9327	37.490 359	266.735	9P(32)	CH_2DOH
602	1132.1406	37.764 145	264.801	10R(20)	N_2H_4
603	1132.3201	37.770 133	264.759	10R(34)	CD_3OH
604	1133.2770	37.802 052	264.536	9P(34)	CH_3OH
605	1136.9420	37.924 303	263.683	9P(34)	CH_3OH
606	1143.1631	38.131 817	262.248	9R(38)	CH_2F_2
607	1145.4301	38.207 435	261.729	9P(38)	CH_2F_2
608	1152.8600	38.455 270	260.042	10R(20)	$^{13}CH_2F_2$
609	1160.0278	38.694 362	258.436	10P(22)	CD_3OH
610	1160.0718	38.695 830	258.426	9P(16)	$H^{13}COOH$
611	1170.9410	39.058 388	256.027	9P(24)	CH_2F_2
612	1176.5700	39.246 151	254.802	9P(4)	$^{13}CH_2F_2$
613	1180.0925	39.363 649	254.041	9P(34)	CH_3OH
614	1181.5898	39.413 593	253.720	10R(36)	CD_3OH
615	1182.3662	39.439 491	253.553	9P(34)	CH_3OH
616	1188.0687	39.629 706	252.336	9R(42)	CH_2F_2
617	1190.0691	39.696 432	251.912	10R(44)	CH_3OH
618	1192.3383	39.772 125	251.432	9R(18)	CH_3OH
619	1193.7273	39.818 457	251.140	10R(38)	CH_3OH
620	1195.4339	39.875 383	250.781	10R(34)	CH_3OH
621	1198.5101	39.997 994	250.138	9P(24)	CH_3NH_2
622	1200.5127	40.044 793	249.720	10P(34)	CH_2DOH
623	1202.0932	40.097 513	249.392	10R(22)	CD_2F_2
624	1205.8960	40.224 361	248.606	9R(26)	$^{13}CH_2F_2$
625	1208.2460	40.302 748	248.122	10P(34)	CH_2DOH
626	1208.3139	40.305 013	248.108	10R(16)	CD_2F_2
627	1210.4088	40.374 892	247.679	9R(34)	CH_2F_2
628	1220.3950	40.707 995	245.652	9P(28)	$^{13}CH_2F_2$

TABLE II. Continued.

No.	Frequency (GHz)	Wave number (cm^{-1})	Wavelength (μm)	CO_2 pump	Molecule
629	1229.4218	41.009 097	243.848	9R(24)	CD_2O
630	1231.9110	41.092 128	243.356	9R(30)	CH_2F_2
631	1234.4904	41.178 167	242.847	10R(32)	CH_3OH
632	1236.3969	41.241 761	242.473	10R(34)	CH_3OH
633	1256.8720	41.924 737	238.523	9P(12)	$^{13}CH_3OH$
634	1260.9142	42.059 570	237.758	9P(6)	CH_2F_2
635	1262.1620	42.101 193	237.523	9P(12)	$^{13}CH_3OH$
636	1267.0815	42.265 289	236.601	9R(6)	CH_2F_2
637	1267.0913	42.265 616	236.599	9R(42)	CH_2F_2
638	1267.1310	42.266 941	236.592	9R(6)	CH_2F_2
639	1267.4590	42.277 881	236.530	9P(10)	$^{13}CH_3OH$
640	1269.7236	42.353 420	236.108	9R(34)	CD_2F_2
641	1272.1714	42.435 070	235.654	9R(32)	CH_2F_2
642	1281.6258	42.750 435	233.916	10R(8)	N_2H_4
643	1282.8920	42.792 671	233.685	9P(10)	CD_2F_2
644	1285.9685	42.895 292	233.126	9R(14)	CD_2O
645	1286.9995	42.929 682	232.939	9R(10)	CH_3OH
646	1287.8322	42.957 458	232.788	9R(22)	CH_3OH
647	1302.8458	43.458 258	230.106	9R(42)	CH_2F_2
648	1308.7555	43.655 384	229.067	10R(20)	CD_2F_2
649	1316.8387	43.925 011	227.661	10R(10)	CD_3OD
650	1316.8605	43.925 738	227.657	9P(18)	CH_2F_2
651	1324.7719	44.189 634	226.297	9P(46)	CH_2DOH
652	1329.3629	44.342 773	225.516	9R(8)	CH_3OH
653	1337.0125	44.597 936	224.226	10P(36)	CH_2DOH
654	1349.1001	45.001 135	222.217	10R(34)	CD_3OH
655	1368.3154	45.642 089	219.096	9R(24)	CH_2DOH
656	1370.4850	45.714 459	218.749	9P(24)	CH_3NH_2
657	1373.5133	45.815 472	218.267	10R(38)	CD_2F_2
658	1376.2711	45.907 462	217.830	9P(30)	O_3
659	1385.6461	46.220 179	216.356	10P(24)	$^{13}CD_3OD$
660	1391.9721	46.431 191	215.372	9R(14)	CH_3OD
661	1393.8569	46.494 062	215.081	10P(52)	CD_3OH
662	1396.2388	46.573 513	214.714	10R(36)	CD_2F_2
663	1397.0050	46.599 071	214.597	9R(34)	$^{13}CH_2F_2$
664	1397.1186	46.602 860	214.579	9R(34)	CH_2F_2
665	1404.4269	46.846 639	213.462	9P(22)	CH_3OH
666	1405.1630	46.871 192	213.351	9R(44)	$^{13}CH_2F_2$
667	1418.7010	47.322 772	211.315	9P(12)	CH_3OH
668	1419.0493	47.334 390	211.263	10R(4)	CH_3OH
669	1428.0576	47.634 874	209.930	9R(14)	CH_3OH
670	1432.8178	47.793 657	209.233	10R(12)	$^{13}CD_3OD$
671	1438.4601	47.981 864	208.412	9P(10)	$^{13}CH_3OH$
672	1442.4543	48.115 096	207.835	10R(38)	CD_2F_2
673	1449.7780	48.359 389	206.785	9P(12)	CH_3OH
674	1450.4631	48.382 241	206.687	9P(14)	CH_2DOH
675	1455.0000	48.533 576	206.043	10R(18)	$^{13}CH_2F_2$
676	1455.4348	48.548 079	205.981	9R(26)	CH_2F_2
677	1472.1994	49.107 286	203.636	10R(16)	$^{13}CH_3OH$
678	1480.7129	49.391 266	202.465	9R(6)	CH_2F_2
679	1496.7570	49.926 439	200.295	9P(16)	$^{13}CH_2F_2$
680	1509.0402	50.336 163	198.664	9P(38)	CH_3OH
681	1514.5626	50.520 370	197.940	9P(24)	CH_3NH_2
682	1518.7950	50.661 548	197.388	9P(20)	$^{13}CH_2F_2$
683	1521.4309	50.749 472	197.046	10R(26)	$^{13}CD_3OH$
684	1525.1641	50.873 998	196.564	9P(44)	CH_3OH
685	1533.4999	51.152 051	195.496	9P(36)	CH_2DOH
686	1536.1530	51.240 549	195.158	9R(20)	$^{13}CH_2F_2$
687	1541.7647	51.427 735	194.448	9R(12)	CH_2F_2
688	1542.5246	51.453 082	194.352	9P(8)	CHDO
689	1544.8187	51.529 605	194.063	9R(14)	CH_3OH
690	1546.0834	51.571 791	193.904	9R(22)	CH_2F_2
691	1549.3400	51.680 420	193.497	9P(22)	$^{13}CH_2F_2$
692	1551.9387	51.767 103	193.173	9R(26)	CH_2F_2
693	1552.1901	51.775 489	193.142	9P(38)	CH_3OH
694	1554.0760	51.838 395	192.907	10P(24)	N_2H_4
695	1555.0201	51.869 887	192.790	9P(8)	CD_2F_2
696	1562.6559	52.124 590	191.848	9P(22)	CH_2F_2
697	1564.5187	52.186 726	191.620	10R(10)	CH_3OH

TABLE II. Continued.

No.	Frequency (GHz)	Wave number (cm^{-1})	Wavelength (μm)	CO_2 pump	Molecule
698	1566.6728	52.258 580	191.356	10R(34)	CD_3OH
699	1571.8497	52.431 262	190.726	9P(34)	CH_3OH
700	1578.3392	52.647 729	189.942	9R(10)	CH_3OH
701	1579.2503	52.678 120	189.832	10R(34)	CD_2F_2
702	1591.0532	53.071 822	188.424	10P(42)	CD_3OH
703	1591.1612	53.075 425	188.411	10P(26)	CH_2DOH
704	1596.1749	53.242 664	187.819	10R(14)	CD_2F_2
705	1604.6477	53.525 286	186.828	9R(10)	CH_3F
706	1609.0267	53.671 354	186.319	9P(34)	CH_3OH
707	1611.4140	53.750 985	186.043	9P(38)	$^{13}CH_2F_2$
708	1611.4219	53.751 249	186.042	9R(18)	CH_3OH
709	1616.1284	53.908 241	185.500	9P(34)	CH_3OH
710	1622.5552	54.122 616	184.766	10R(24)	CD_3OD
711	1626.6026	54.257 622	184.306	9R(32)	CH_2F_2
712	1632.6669	54.459 906	183.621	9P(10)	CH_2DOH
713	1635.6280	54.558 677	183.289	9P(28)	$^{13}CH_2F_2$
714	1642.1019	54.774 623	182.566	9R(14)	CD_3OH
715	1643.7690	54.830 232	182.381	10R(20)	$^{13}CH_2F_2$
716	1647.8774	54.967 273	181.926	10P(6)	N_2H_4
717	1658.6899	55.327 940	180.741	10R(34)	CD_3OH
718	1659.2786	55.347 576	180.676	9P(34)	CH_3OH
719	1668.0350	55.639 659	179.728	10R(4)	CH_3OH
720	1726.5485	57.591 459	173.637	10R(20)	$^{13}CD_3OD$
721	1734.4464	57.854 904	172.846	9P(12)	CH_2DOH
722	1745.4395	58.221 595	171.758	10R(18)	$^{13}CH_3OH$
723	1757.5263	58.624 767	170.576	9P(36)	CH_3OH
724	1783.6011	59.494 529	168.083	10R(34)	CD_3OH
725	1788.8766	59.670 500	167.587	10R(40)	CH_3OH
726	1789.3659	59.686 822	167.541	9P(18)	CH_2DOH
727	1791.3848	59.754 165	167.352	9P(32)	CH_2DOH
728	1796.4617	59.923 512	166.879	9R(10)	CD_2F_2
729	1798.6470	59.996 406	166.677	9R(22)	CH_2F_2
730	1799.1393	60.012 827	166.631	9R(20)	CH_2F_2
731	1810.2943	60.384 918	165.604	10R(22)	CD_3OD
732	1818.9640	60.674 108	164.815	9R(4)	$^{13}CH_2F_2$
733	1819.3140	60.685 783	164.783	9R(10)	CH_3OH
734	1819.7203	60.699 336	164.746	9R(8)	CH_2DOH
735	1820.2615	60.717 388	164.697	9P(24)	CH_3OH
736	1820.7150	60.732 515	164.656	9P(12)	$^{13}CH_2F_2$
737	1821.3352	60.753 203	164.600	9P(16)	CH_3OH
738	1821.7355	60.766 555	164.564	9P(14)	CH_3OH
739	1822.3627	60.787 477	164.508	9P(14)	CH_3OH
740	1832.7686	61.134 580	163.574	9P(12)	CH_3OH
741	1837.8610	61.304 444	163.120	9R(22)	CH_2F_2
742	1838.8393	61.337 077	163.034	10R(38)	CH_3OH
743	1848.0838	61.645 440	162.218	9P(36)	CH_3OH
744	1877.5085	62.626 942	159.676	9R(26)	CH_3OH
745	1882.9063	62.806 994	159.218	10R(34)	CH_2DOH
746	1885.9593	62.908 831	158.960	9P(20)	CH_2F_2
747	1891.2742	63.086 117	158.513	9P(10)	CH_2F_2
748	1898.2799	63.319 802	157.928	9P(12)	$^{13}CH_3OH$
749	1944.6796	64.867 529	154.160	9P(24)	CH_2F_2
750	1950.5816	65.064 399	153.694	9R(28)	$^{13}CD_3OH$
751	1956.9358	65.276 352	153.195	9P(28)	CH_2F_2
752	1971.3372	65.756 731	152.076	10R(16)	$^{13}CH_3OH$
753	1982.0506	66.114 092	151.254	9R(26)	CH_3OH
754	1987.7989	66.305 834	150.816	10R(34)	CH_2DOH
755	1991.0283	66.413 555	150.572	10P(26)	CH_2DOH
756	1992.7952	66.472 493	150.438	10R(18)	CD_2F_2
757	2003.7883	66.839 183	149.613	10R(32)	CH_2DOH
758	2006.8052	66.939 816	149.388	10P(36)	CH_2DOH
759	2008.3601	66.991 682	149.272	9P(22)	$^{13}CH_3OH$
760	2017.2185	67.287 166	148.617	10R(30)	$^{13}CD_3OD$
761	2017.5761	67.299 095	148.590	10R(16)	$^{13}CH_3OH$
762	2027.7526	67.638 546	147.845	9P(24)	CH_3NH_2
763	2034.5736	67.866 070	147.349	10P(32)	CD_3OH
764	2048.8036	68.340 732	146.326	10R(26)	$^{13}CD_3OH$
765	2052.0041	68.447 489	146.097	9P(10)	$^{13}CH_3OH$
766	2058.1418	68.652 221	145.662	9P(30)	CH_3OD

TABLE II. (*Continued*).

No.	Frequency (GHz)	Wave number (cm^{-1})	Wavelength (μm)	CO_2 pump	Molecule
767	2059.5316	68.698 579	145.563	10R(24)	$^{13}CD_3OH$
768	2063.9411	68.845 665	145.252	10R(32)	CH_3OH
769	2066.3791	68.926 987	145.081	9P(24)	CH_2F_2
770	2080.1893	69.387 646	144.118	10P(18)	CD_3OH
771	2093.7288	69.839 275	143.186	9R(42)	CH_2F_2
772	2135.1930	71.222 372	140.405	9R(38)	$^{13}CH_2F_2$
773	2152.6624	71.805 089	139.266	10R(20)	CD_2F_2
774	2168.0000	72.316 696	138.281	9R(22)	$^{13}CH_2F_2$
775	2188.9290	73.014 812	136.959	10R(46)	CD_3OD
776	2194.2369	73.191 865	136.627	10R(14)	CD_3OH
777	2207.0583	73.619 540	135.834	9R(8)	CH_2DOH
778	2212.1110	73.788 080	135.523	9R(44)	$^{13}CH_2F_2$
779	2216.2635	73.926 593	135.269	9P(24)	CH_2F_2
780	2217.8499	73.979 510	135.173	10R(32)	CH_2DOH
781	2217.8633	73.979 956	135.172	10R(32)	CH_2DOH
782	2237.2964	74.628 175	133.998	9P(22)	CH_2F_2
783	2252.0542	75.120 442	133.120	9P(24)	CH_3OH
784	2278.7030	76.009 350	131.563	10R(32)	CD_3OH
785	2314.1113	77.190 444	129.550	10R(34)	CH_3OH
786	2340.2918	78.063 732	128.100	10R(16)	$^{13}CD_3OD$
787	2341.5089	78.104 330	128.034	10R(34)	CD_3OH
788	2348.4384	78.335 473	127.656	10R(22)	$^{13}CD_3OH$
789	2360.1748	78.726 957	127.021	10P(8)	$^{13}CD_3OH$
790	2369.0567	79.023 225	126.545	9P(30)	CH_2F_2
791	2402.2240	80.129 568	124.798	10R(26)	CD_3OD
792	2409.2933	80.365 374	124.432	10P(34)	CH_2DOH
793	2412.7579	80.480 941	124.253	9P(24)	$^{13}CD_3OD$
794	2447.9685	81.655 440	122.466	9R(22)	CH_2F_2
795	2447.9746	81.655 643	122.466	9P(8)	CH_2F_2
796	2451.2031	81.763 334	122.304	10R(28)	CD_3OD
797	2479.6222	82.711 294	120.902	10R(44)	CH_3OH
798	2488.5534	83.009 206	120.469	10R(36)	CD_2F_2
799	2518.0677	83.993 697	119.057	10R(26)	CD_3OD
800	2522.7816	84.150 936	118.834	9P(36)	CH_3OH
801	2528.7728	84.350 781	118.553	10R(14)	$^{13}CD_3OD$
802	2540.3310	84.736 321	118.013	9P(22)	$^{13}CH_3OH$
803	2541.4856	84.774 834	117.960	9P(14)	CH_3OH
804	2546.4950	84.941 930	117.727	9R(20)	CH_2F_2
805	2557.3654	85.304 528	117.227	9P(26)	CH_3OD
806	2560.4670	85.407 986	117.085	9P(32)	CH_2DOH
807	2585.8568	86.254 898	115.935	9P(8)	CH_2F_2
808	2588.3617	86.338 453	115.823	10R(16)	$^{13}CH_3OH$
809	2635.9580	87.926 095	113.732	9R(8)	CH_3OH
810	2654.3107	88.538 275	112.946	9P(44)	CH_3OH
811	2664.0583	88.863 420	112.532	9P(12)	CH_2DOH
812	2707.7493	90.320 795	110.716	9P(36)	CH_3OH
813	2714.7147	90.553 135	110.432	10R(18)	$^{13}CH_3OH$
814	2726.9235	90.960 377	109.938	10R(16)	$^{13}CD_3OD$
815	2727.2117	90.969 990	109.926	10R(16)	$^{13}CD_3OD$
816	2742.9460	91.494 830	109.296	9P(24)	CH_2F_2
817	2751.8729	91.792 599	108.941	9P(32)	CH_2DOH
818	2754.9957	91.896 765	108.818	9P(12)	CH_2DOH
819	2758.7817	92.023 052	108.668	10P(10)	CD_3OH
820	2787.7894	92.990 645	107.538	10R(12)	CD_3OD
821	2841.1429	94.770 326	105.518	9P(16)	CH_2F_2
822	2851.1692	95.104 767	105.147	10R(18)	$^{13}CH_3OH$
823	2894.1323	96.537 862	103.586	10R(26)	$^{13}CH_3OH$
824	2897.0824	96.636 267	103.481	9P(22)	$^{13}CH_3OH$
825	2907.0889	96.970 048	103.125	9P(30)	CH_3OD
826	2938.4651	98.016 645	102.023	9P(16)	CH_2DOH
827	2973.9406	99.199 981	100.806	9R(14)	CH_3OH
828	2992.9570	99.834 299	100.166	10R(32)	CH_3OH
829	3002.0875	100.138 860	99.861	10P(16)	CH_3OH
830	3074.2100	102.544 608	97.519	10R(40)	CH_3OH
831	3105.9368	103.602 900	96.522	9R(10)	CH_3OH
832	3137.5106	104.656 088	95.551	9R(12)	CH_2F_2
833	3235.2536	107.916 444	92.664	10R(34)	CH_3OH
834	3239.4616	108.056 808	92.544	9P(22)	CH_3OH
835	3456.1612	115.285 128	86.741	10R(34)	CD_3OH

TABLE II. (*Continued*).

No.	Frequency (GHz)	Wave number (cm^{-1})	Wavelength (μm)	CO_2 pump	Molecule
836	3476.2825	115.956 303	86.239	9R(8)	CH_3OH
837	3481.4330	116.128 105	86.112	9P(10)	$^{13}CH_3OH$
838	3502.2102	116.821 158	85.601	9P(40)	CH_3OH
839	3513.8534	117.209 533	85.317	9P(22)	$^{13}CH_3OH$
840	3551.8058	118.475 489	84.406	10R(22)	$^{13}CD_3OH$
841	3675.8599	122.613 488	81.557	10R(16)	CD_3OH
842	3848.1855	128.361 651	77.905	10R(16)	CH_3OH
843	3868.8189	129.049 908	77.489	10R(26)	$^{13}CH_3OH$
844	3873.0051	129.189 544	77.406	9R(8)	CH_3OH
845	3982.6311	132.846 274	75.275	9R(24)	$^{13}CD_3OD$
846	4080.6372	136.115 406	73.467	10R(20)	$^{13}CD_3OH$
847	4089.5796	136.413 692	73.306	9P(40)	CH_3OH
848	4223.0620	140.866 185	70.989	10R(8)	CD_3OH
849	4251.6740	141.820 579	70.512	9P(34)	CH_3OH
850	4302.4449	143.514 114	69.680	10R(16)	CH_3OH
851	4441.6752	148.158 337	67.495	9R(18)	CH_3OH
852	4442.7248	148.193 348	67.479	10R(30)	CD_3OH
853	4730.8664	157.804 717	63.369	9P(34)	CH_3OH
854	4751.3409	158.487 673	63.096	9P(12)	$^{13}CH_3OH$
855	4761.1824	158.815 950	62.966	10R(16)	CH_3OH
856	4865.7098	162.302 609	61.613	9R(18)	CH_3OH
857	4982.1531	166.186 739	60.173	9P(40)	CH_3OH
858	5414.3441	180.603 079	55.370	9P(40)	CH_3OH
859	5566.0527	185.663 533	53.861	10R(36)	CH_3OH
860	6860.6642	228.847 125	43.697	10R(18)	CD_3OH
861	7110.9814	237.196 808	42.159	9P(32)	CH_3OH
862	7249.2660	241.809 485	41.355	10R(18)	CD_3OH
863	7509.0362	250.474 487	39.924	9P(34)	CH_3OH
864	7919.6602	264.171 429	37.854	9P(32)	CH_3OH

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Note added in proof: While the present work was already in press we received from D. J. E. Knight the preprint of a work containing the frequency measurements of 42 new FIR laser lines, 5 from CH_3Cl and 37 from CH_2F_2. The title is "Frequency measurements on far-infrared emissions from $^{12}C^{16}O_2$-pumped methyl chloride and from $^{12}C^{18}O_2$-pumped difluoromethane," by J. A. Golby, N. R. Cross, and D. J. E. Knight. This work will be published in the September 1986 issue of the International Journal of Infrared and Millimeter Waves.

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