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New FIR Laser Lines from CHD_2OH Optically Pumped by a cw CO_2 Laser

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Abstract. This work reports 83 new optically pumped far infrared laser lines, using deuterated methyl alcohol, CHD_2OH, as active medium. For each line we list the measured wavelength, its polarization relative to the pump line, the optimum gas pressure and the CO_2 laser pump power at the maximum absorption.

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Methyl alcohol and its isotopes were early [1] recognized as sources of strong FIR lasing when optically pumped by a regular cw CO_2 laser. The main reason is the excellent overlap that exists between the strongly absorbing C–O stretch mode and the CO_2 laser spectrum. Many other particular spectroscopic features of these species have to be considered, such as the complexity of the rotational spectrum caused by the torsional or internal rotation degree of freedom, which make the spectrum more dense. Furthermore, the fairly large permanent dipole moments both along and orthogonal to the quasisymmetric axis, make the electric dipole selection rules less restrictive than for symmetric top molecules.

In this work we report 83 new FIR-laser lines of the CHD_2OH molecules.

1. Experimental Set-Up

The experimental set-up is the one used with success in other experiments [2]. It consists, essentially, of a Fabry-Perot FIR cavity with its gain cell pumped by a line-tunable cw CO_2 laser and associated electronics and vacuum equipment. A gold coated pyrex mirror at one end of the FIR cavity is moved by a micrometer, driven by a step motor, in order to tune the cavity into resonance with the rotational transitions of the active gas. We have determined the wavelengths by counting the modes in a calibrated 3.5 mm scan of the FIR cavity length. The intensity of the lines were measured with a Golay detector using various attenuators when necessary to prevent saturation. A metal mesh polarizer was used for polarization.

2. Results

We have obtained 83 new lines for CHD_2OH molecule and confirmed 8 lines obtained first by Ziegler and Dürr [3]. All these lines had their intensities normalized with respect to the intensity of the 118.8 μm line of methyl alcohol molecule (CH_3OH) oscillating in the same cavity, to which was attributed the value 100. Table 1 presents all lines observed in this work, including the previous ones, arranged with respect to the CO_2 laser pump lines. For each FIR-laser line, Table 1 lists the measured wavelength, its polarization relative to that of the pump line, the optimum pressure of the gas and the CO_2 laser pump power at the maximum absorption.

Figure 1 displays the observed lines and their relative intensities. Most of the strong intensity lines are in the region between 100 and 400 μm. Below 100 μm the lines are very weak except for the line at 55.6 μm.

At the present time, no theoretical formalism is available for the methyl alcohol deuterated molecule, CHD_2OH, that allows a reliable assignment for the measured laser lines. Certainly, the previous theoretical formalism used with success for assignment of FIR-active laser lines of methyl alcohol CH_3OH [4], and their isotopes CD_3OH [5] and $^{13}CH_3OH$ [6] will be helpful for the molecule CHD_2OH, provided ac-

Table 1. Summary of absorved submillimeter laser lines obtained from CHD_2OH with its respective pumping CO_2 laser line, relative polarization, relative intensity, and optimum gas pressure

CO_2 pump	CHD_2OH laser line λ [μm]	Relative polar-ization	CO_2 pump power [W]	CHD_2OH relative intensity	Pressure [mTorr]
9*R*(38)	109.3	⊥	8.5	12.9	140
	111.4	⊥	8.5	6.4	140
	117.3	⊥	8.5	8.5	140
	172.4	∥	8.5	1.3	120
9*R*(34)	279.0	∥	12	0.3	70
	290.2	∥	12	0.4	70
9*R*(32)	145.3	⊥	14	5.4	110
	179.8	∥	14	5.2	120
9*R*(30)	120.9	∥	15	12.1	180
	132.2	⊥	15	3.0	100
9*R*(26)	135.0	⊥	15	1.2	110
	144.8	⊥	15	0.6	110
	202.6	∥	15	3.0	110
9*R*(24)	164.4	∥	15	4.8	90
9*R*(20)	249.6	∥	17	0.7	80
9*R*(16)	217.9	∥	16	52.1	160
9*R*(14)	280.8	∥	15	18.1	140
	317.0	∥	16	36.2	120
	598.3	∥	16	11.3	120
9*R*(10)	221.2	∥	13	0.4	140
9*R*(04)	165.1	∥	12	21.1	110
9*P*(04)	246.8	∥	08	34.0	110
	512.8	∥	08	11.3	120
9*P*(06)	482.9	∥	08	24.9	110
9*P*(08)	196.8	∥	09	6.0	120
9*P*(16)	226.8	∥	10	2.0	120
9*P*(18)	104.6	∥	11	9.9	120
9*P*(20)	246.1	∥	10	1.4	110
	254.3	∥	12	90.6	100
	501.9	∥	10	0.9	100
9*P*(22)	484.4	∥	12	1.5	100
9*P*(24)	203.1	∥	12	6.6	180
9*P*(26)	128.5	⊥	13	5.6	120
	204.7	∥	14.5	3.8	160
	255.3	⊥	13	1.7	70
	437.4	∥	10	2.5	80
9*P*(28)	404.6	∥	10	10.5	80
9*P*(30)	385.4	∥	10	63.4	100
9*P*(34)	137.0	∥	10	9.1	80
	606.7	⊥	10	6.3	100
	607.3	∥	10	5.1	80
9*P*(36)	249.7	∥	11	1.7	110
9*P*(38)	123.9	⊥	10	19.9	120
	187.5	∥	11	6.6	110
10*R*(40)	111.6	∥	09	16.1	60
	80.0	⊥	10	3.6	120
10*R*(36)	278.4	∥	13	2.8	160
10*R*(34)	111.9	∥	12	9.0	120
10*R*(32)	83.9	⊥	14	1.3	80
	93.0	∥	14.5	2.5	110
10*R*(28)	227.5	∥	17	1.1	110

Table 1 (continued)

CO_2 pump	CHD_2OH laser line λ [μm]	Relative polar-ization	CO_2 pump power [W]	CHD_2OH relative intensity	Pressure [mTorr]
10*R*(26)	41.8	⊥	11	0.5	80
	45.1	∥	11	1.8	80
	136.2	∥	13	4.2	90
10*R*(24)	107.4	∥	12.5	0.6	140
10*R*(22)	288.3	∥	11	2.5	140
10*R*(20)	172.1	∥	18	4.0	180
10*R*(18)	55.6	∥	18	20.1	110
	127.4	∥	17	22.4	160
	259.9	∥	15	7.7	160
10*R*(14)	83.7	⊥	17	3.7	190
10*R*(10)	228.7	∥	17	10.7	120
	270.0	∥	17	0.5	100
10*R*(08)	305.6	∥	15	27.8	120
	452.5	∥	17.5	33.1	160
10*R*(06)	105.0	∥	16	2.8	200
10*R*(04)	74.1	∥	12	0.3	120
10*R*(02)	344.9	∥	08	0.9	80
10*P*(04)	57.9	⊥	13	4.5	110
10*P*(08)	123.8	∥	15	19.3	90
	152.6	⊥	15	30.2	110
10*P*(10)	517.8	∥	16.5	1.2	90
10*P*(12)	171.1	∥	17	42.7	100
10*P*(14)	103.0	⊥	17	66.1	190
10*P*(16)	103.0	∥	17	85.3	200
10*P*(18)	212.9	⊥	17	102.0	160
10*P*(20)	291.3	∥	18	45.3	110
	427.1	∥	18	40.3	110
10*P*(28)	74.8	⊥	18	1.2	110
	124.4	⊥	18	6.0	110
	558.8	⊥	18	10.1	120
10*P*(40)	125.4	∥	10	2.7	120
	142.9	⊥	10	2.7	120

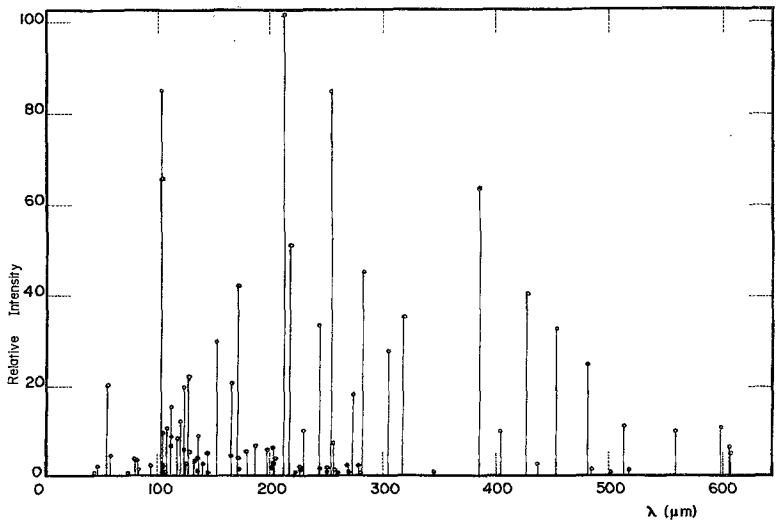

Fig. 1. This diagram shows the intensity of each laser line of the molecule CHD_2OH, relative to the 118.8 μm alcohol methyl line intensity

count is taken of the lack of symmetry of the methyl radical. The identification (measurements) of the new lines provides conditions for testing this formalism.

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