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FAR INFRARED LASING FREQUENCIES OF CH_2DOD*

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Abstract

We obtained laser action from the CH_2DOD molecule optically pumped by CO_2 laser radiation. Eight lasing transitions were identified as originating from CH_2DOD; an additional 21 transitions also lased, but were assigned to the CH_2DOH molecule, and 2 to CH_3OH, even though the isotopic purity of the sample was given as 98%. The relative intensity, relative polarization and frequency of all the lines were measured. The eight lines are distributed between 145.8 µm and 479.2 µm.

Normal methyl alcohol, CH_3OH, is the best known optically pumped FIR lasing molecule. The ^{13}C and D isotopic species still have their vibrational absorption spectra in the CO_2 laser frequency range and hence are also good lasing gases. The isotopic variety CH_2DOH has been pumped by a CO_2 laser and shown to lase by Ziegler and Dürr (1) and subsequently by Scalabrin et al.(2) who

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found new lines and measured the frequencies of many lines. These data are condensed in a review paper by Kon et al.(3), and are listed in a review of frequency measured FIR lines (4).

In this work we report the irradiation of the CH_2DOD molecule with CO_2 laser radiation, obtaining laser action on 31 lines, from which just 8 appear to originate from transitions occurring in the CH_2DOD molecule. The other 23 lines were assigned as follows: 21 have been found previously in CH_2DOH(1,2) and 2 are known lines in CH_3OH. The wavelengths of the 8 new lines were obtained in a 98% pure sample of CH_2DOD, and range from 145.8 μm to 479.2 μm. They were obtained in a transversely pumped 1 m Fabry-Perot resonator with a conventional CO_2 pump laser as described previously (5).

We present, in Table I, the observed CH_2DOD laser lines along with their relative polarization, optimum pressure, relative intensity, and pump power. Two of the strongest lines, λ=368.0 μm and λ=413.1 μm were pumped by the 9P(32) CO_2 laser line. On this same pump line, Dyubko et al. (6) reported in CH_3OH two FIR lines at wavelengths (372 ± 1) μm and (418 ± 1) μm but these have not been found in our laser using a sample of CH_3OH (7); therefore we think they are actually due to CH_2DOD.

Table II is a summary of the CH_2DOD laser frequency measurements. We have measured all the frequencies of the 31 lines we have observed in our sample and then discovered that 21 of these correspond to the frequencies of the lines already measured in CH_2DOH. The measurements were in agreement ($\Delta\nu/\nu$) within a 1 σ uncertainty of 3×10^{-7}. This uncertainty is mainly due to the reproducibility in setting this transversely pumped FIR laser two independent times; thus, there is a single-time frequency resettability of $1/\sqrt{2}$ times 3×10^{-7}, ie. 2×10^{-7}. Our early measurement made in a longitudinally pumped laser exhibited an uncertainty of $\pm5\times10^{-7}$, and we think that this number represents the uncertainty in resettability in longitudinally pumped lasers due to feedback in the CO_2 laser.

Before the frequency measurements, wavelength measurements were made with ±0.1 μm accuracy by counting the modes in a calibrated 5 mm scan of one end mirror of the Fabry-Perot resonator. The polarizations of the FIR lines relative to the CO_2 lines were determined by using a metal-mesh or stacked- plate polarizer in front of the FIR detector. Optimum lasing pressures were measured with a thermocouple gauge, with the laser adjusted to obtain maximum FIR output intensity. Output intensities were measured with either a Golay cell or a metal-insulator-metal, point-contact diode.

During the measurements, we needed a continuous flux of the CH_2DOD vapor in order to maintain laser oscillation, apparently due to a rapid isotopic rearrangement of the deuterium and hydrogen in the CH_2DOD. The lines which increase with the flow rate of CH_2DOD are those attributed to CH_2DOD, and those which decrease with flow of CH_2DOD were attributed to CH_2DOH. Wall preparation, performed by filling the laser with CD_3OD several times for many minutes before the addition of CH_2DOD, did not seem to change the results.

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TABLE I - SUMMARY OF CH_2DOD LASER LINES

CH_2DOD Laser Line λ (μm)	Rel. Pol.	CH_2DOD Press. Pa(mTorr)[a]	Relative FIR Int.	CO_2 Power (W)	CO_2 Pump Line
145.8	∥	24(180)	6	33	10P(30)
158.4	⊥	40(300)	100	41	10P(10)
267.7	∥	13(100)	10	36	10R(16)
278.9	⊥	20(150)	8	36	10R(16)
479.2	∥	20(150)	18	36	10R(16)
368.0(372±1)[b]	⊥	20(150)	90	24	9P(32)
413.1(418±1)[b]	∥	17(130)	60	24	9P(32)
230.6	⊥	27(200)	12	18	9P(06)

(a) 1 Torr = 133.3 Pa.

(b) Reported by Dyubko et al. (1981) in CH_3OH, but not found in our laser with a sample of CH_3OH[5].

TABLE II - SUMMARY OF CH_2DOD LASER LINE FREQUENCY MEASUREMENTS

CH_2DOD Laser Line λ (μm)	Measured Freq. (MHz) Uncertainty $\Delta\nu/\nu = 2x10^{-7}$	Vacuum Wavenumber (cm^{-1})	CH_2DOD Press. Pa(mTorr)	CO_2 Pump Line
145.769 789	2 056 615.851	68.601 321	24(180)	10P(30)
158.390 159	1 892 746.748	63.135 236	27(200)	10P(10)
230.610 467	1 299 995.010	43.363 166	27(200)	9P(06)
267.660 699	1 120 046.608	37.360 733	13(100)	10R(16)
278.930 573	1 074 792.392	35.851 215	21(160)	10R(16)
367.974 974	814 708.824	27.175 761	20(150)	9P(32)
413.113 483	725 690.326	24.206 424	20(150)	9P(32)
479.226 106	625 576.224	20.866 977	20(150)	10R(16)