The Shortest Known Laser Emission from Optically Pumped CHD_2OH

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ABSTRACT

The partially deuterated isotope of methanol, CHD_2OH, has been reinvestigated as a source of far-infrared (FIR) laser emissions using an optically pumped molecular laser (OPML) system recently designed for wavelengths below 150 μm. With this system, six new FIR laser emissions from this isotope ranging from 32.8 to 174.7 μm have been discovered. This includes the discovery of the shortest known OPML emission from CHD_2OH at 32.8 μm. These lines are reported with their operating pressure, polarizations relative to the CO_2 pump laser and wavelengths, measured to ± 0.5 μm. In addition, polarizations for three previously observed FIR laser lines from CHD_2OH were measured for the first time.

INTRODUCTION

The first observation of optically pumped far-infrared (FIR) laser emissions from CHD_2OH was by Ziegler and Dürr in 1978 [1]. In their work, eleven laser emissions were discovered from this isotope with wavelengths ranging from 165.0 to 518.0 μm. Since then over 98 FIR laser emissions have been discovered from this isotope, with wavelengths ranging from 80.0 to 607.3 μm [2].

In this work, CHD_2OH was reinvestigated using an optically pumped molecular laser (OPML) system designed for the discovery of short-wavelength ($\lambda < 150$ μm) laser emissions [3, 4]. Using the newly designed cavity, six new OPML emissions have been discovered and three previously unknown polarizations have been measured for optically pumped CHD_2OH.

EXPERIMENTAL DETAILS

The experimental apparatus used to search for new FIR laser lines (described in detail elsewhere [3,4]) consisted of a tunable Fabry-Perot cavity optically pumped with an X-V geometry by a CO_2 laser [5]. The FIR cavity utilized a nearly confocal mirror system with one end mirror mounted on a micrometer to tune the cavity into resonance with the FIR laser radiation. Laser wavelengths were measured by scanning over 20 adjacent longitudinal modes for a particular laser emission.

Using this method, FIR laser wavelengths were measured with an uncertainty of ± 0.5 μm. Figure 1 illustrates a portion of a typical cavity scan with the intensity plotted as a function of cavity length. The intensities of the laser lines were measured with a pyroelectric detector using various filters that attenuate CO_2 laser radiation and help distinguish different FIR wavelengths [3]. The relative polarizations of the FIR laser emissions with respect to the CO_2 laser lines were measured with a multi-Brewster-angle polarization selector as well as a gold wire-grid polarizer (1000 lines per inch). The sample of CHD_2OH, 98% D_2 enriched, was obtained from Cambridge Isotope Laboratories.

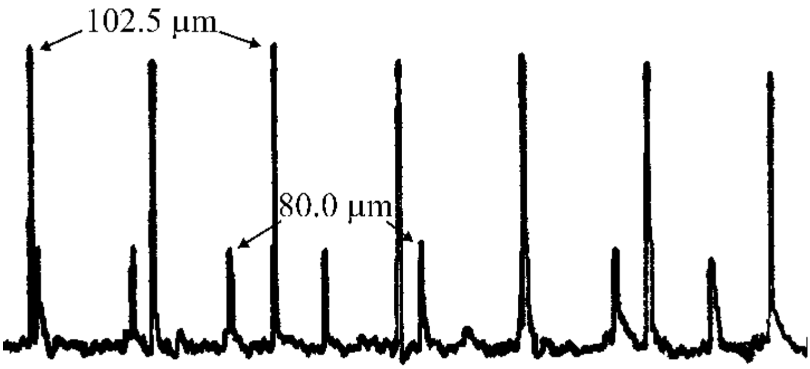

Figure 1. Portion of a cavity scan illustrating adjacent longitudinal modes of the 80.0 [2] and the 102.5 µm laser emissions. The FIR laser medium was CHD_2OH and the CO_2 pump line was 10*R*40.

RESULTS AND CONCLUSIONS

The newly discovered FIR laser emissions from optically pumped CHD_2OH are listed in Table 1 and are arranged in order of their CO_2 pump line. This work reports the discovery of six new laser emissions ranging from 32.8 to 174.7 µm along with their polarizations with respect to the CO_2 pump laser and their operating pressure and relative intensity, when available. The discovery of these emissions, which includes the discovery of the shortest known laser emission from optically pumped CHD_2OH at 32.8 µm, illustrates the effectiveness of the X-V pumping geometry on short-wavelength FIR laser emissions. Table 1 also lists the relative polarizations of three previously observed OPML emissions, measured for the first time from CHD_2OH and the relative intensity of the FIR laser emission, as compared to the 118.8 µm laser line from optically pumped CH_3OH. The intensity of this line is considered to be very, very strong (VVS) and is expected to provide a power greater than 10 mW when all the parameters (pump laser, FIR resonator, coupling mirror, pressure, etc.) have been optimized. Optimization of the FIR cavity was done to the best of our ability, but in no way should be taken as an absolute measure since the relative intensities of FIR emissions are subject to the experimental apparatus used [6]. The lines labeled with medium (M) and weak (W) have ranges in power from 0.1-0.01 mW and 0.01-0.001 mW, respectively. These new laser emissions will be useful for filling the gaps in the short-wavelength portion of the FIR region and will help provide a more complete energy level structure of this isotope. The OPML emissions can also serve as a source of strong coherent FIR radiation for a number of spectroscopic applications including laser magnetic resonance and laser Stark spectroscopy.

Table 1. Far-infrared laser emissions from optically pumped CHD_2OH

CO_2 Pump	Wavelength (μm)	Pressure (Pa)	Relative Intensity[a]	Relative Polarization
9*R*18	165.0[c]	26.5	M	ǁ
10*R*44	157.4[b]	33.5	M	ǁ
10*R*40	102.5[b]	17.5	W	
10*R*38	53.1[b]	24.0	M	ǁ
	168.0[c]	31.5	M	ǁ
10*R*26	32.8[b]	21.5	W	
10*R*20	174.7[b]	5.5	W	ǁ
10*R*16	47.9[b]	32.5	M	⊥
	179.0[c]	22.0	M	ǁ

[a] The 118.8 μm line of CH_3OH is considered to be VVS [3]
[b] New laser emission
[c] Wavelength previously reported in [1]

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