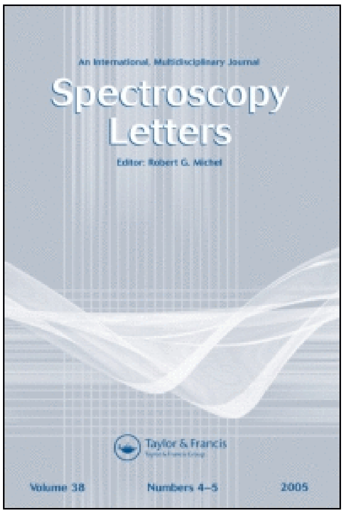

Spectroscopy Letters
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597299

Tea Laser Effective Oscillation on 01^11-11^10 Hot Band Lines of Isotopic Species Carbon Dioxide

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To cite this Article Bertel, I. M. , Churakov, V. V. , Petukhov, V. O. and Trushin, S. A.(1983) 'Tea Laser Effective Oscillation on 01^11-11^10 Hot Band Lines of Isotopic Species Carbon Dioxide', Spectroscopy Letters, 16: 6, 403 — 408
To link to this Article: DOI: 10.1080/00387018308062357
URL: http://dx.doi.org/10.1080/00387018308062357

SPECTROSCOPY LETTERS, 16(6), 403-408 (1983)

TEA LASER EFFECTIVE OSCILLATION ON 01^11-11^10 HOT BAND LINES OF ISOTOPIC SPECIES CARBON DIOXIDE

KEY WORDS: TEA CO_2-laser; 01^11-11^10 hot band; $^{12}CO_2$, $^{13}CO_2$ and $^{14}CO_2$ isotope modifications; uranium isotope separation.

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The increase of frequency number generated by conventional CO_2 laser systems is undoubtedly of interest for various applications associated with selective action on substance.

In this paper we report on TEA CO_2 laser oscillation spectrum expanding owing to 01^11-11^10 hot band lines of $^{12}CO_2$ (10.9-11.4 μm) and $^{13}CO_2$(11.4-11.9 μm) molecules at high laser system efficiency.* Besides

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* For the first time the weak $^{12}CO_2$ hot band oscillation was registered by C.Frapard et al. in longitudinal discharge system.[1]

 0038-7010/83/1606-0403$3.50/0

the possibility of effective powerful radiation source development with $\lambda = 12.15\ \mu m$ that may be used for commercial laser separation of uranium isotopes is also discussed.

To obtain considerable hot band gain $\mathcal{K}_h$ of CO_2 molecule it is necessary to heat up ν_2 mode, characterized by vibrational temperature T_2, along with the excitation of ν_3 mode (temperature T_3). For the conventional values of $T_3 \sim 1600 - 2200$ K realized in an electrical discharge $\mathcal{K}_h$ gain is shown to achieve its maximum if $T_2 \sim \frac{1}{3} T_3$ [2]. Such a relationship between T_2 and T_3 can be reached in gas mixtures with greater CO_2 and lesser He contents, as compared to those optimal for 10.6 μm regular band oscillation [3]. In addition, an increased specific energy input is also required.

The hot band gain investigations have shown the $CO_2:N_2:He = 1:0.8:1$ mixture to be optimal for the UV-preionization TEA CO_2 laser described in details in[4]. The maximum gain of $0.7\ m^{-1}$ for that mixture was achieved at total pressure of ~ 220 Torr, $0.25\ \mu F$ capacitor bank voltage of ~ 30 kV and operational volume of $4x2x70\ cm^3$. In this case the vibrational temperatures T_3 and T_2 are ~ 1850 K and ~ 630 K, respectively, according to the technique described in[4].

The hot band line oscillation spectrum studies have been performed for the above optimal active medium parameters. The laser cavity was formed by a full reflective 5-m radius concave AL-coated mirror and

100-line/mm Al-coated grating used as an output coupler. The cavity length was $\sim$1 m. Grating reflectivity could be changed depending on the plane of incident radiation polarization from $\sim$60% to 90%. In this case output coupling changes from $\sim$37% to 7%, respectively. Polarization changing was obtained by NaCl Brewster window rotation around the cavity axis. Such a grating mode enables the optimal output coupling to be chosen for rotation-vibration lines with variable J, that is essential for effective oscillation on lines with strongly different gains.

Figure 1 shows the output energy distribution on hot band P-branch for $^{12}CO_2$ and $^{13}CO_2$ isotope modifications. Figure 1 a) also shows the output energy value for 00^01-10^00 regular band P(42) line obtained under similar conditions. Oscillation spectrum identification was accomplished with Carl Zeiss Jena mirror monochromator SPM-2 and the spectroscopic data.[5,6] Oscillation was achieved on 36 lines over the range of 10.9-11.4 μm with pulse energy exceeding 200 mJ for $^{12}CO_2$ molecule. The strongest line oscillation energy was about 2.3 J, that is approximately 35% when compared to the regular band strong line output energy for the laser system in optimal mode. In this case the hot band line oscillation efficiency was $\sim$2.3%, and specific output energy was $\sim$21 J L^{-1} atm^{-1}.

In case of $^{13}CO_2$ isotope molecule oscillation was obtained on 33 hot band lines over the range 11.45 to

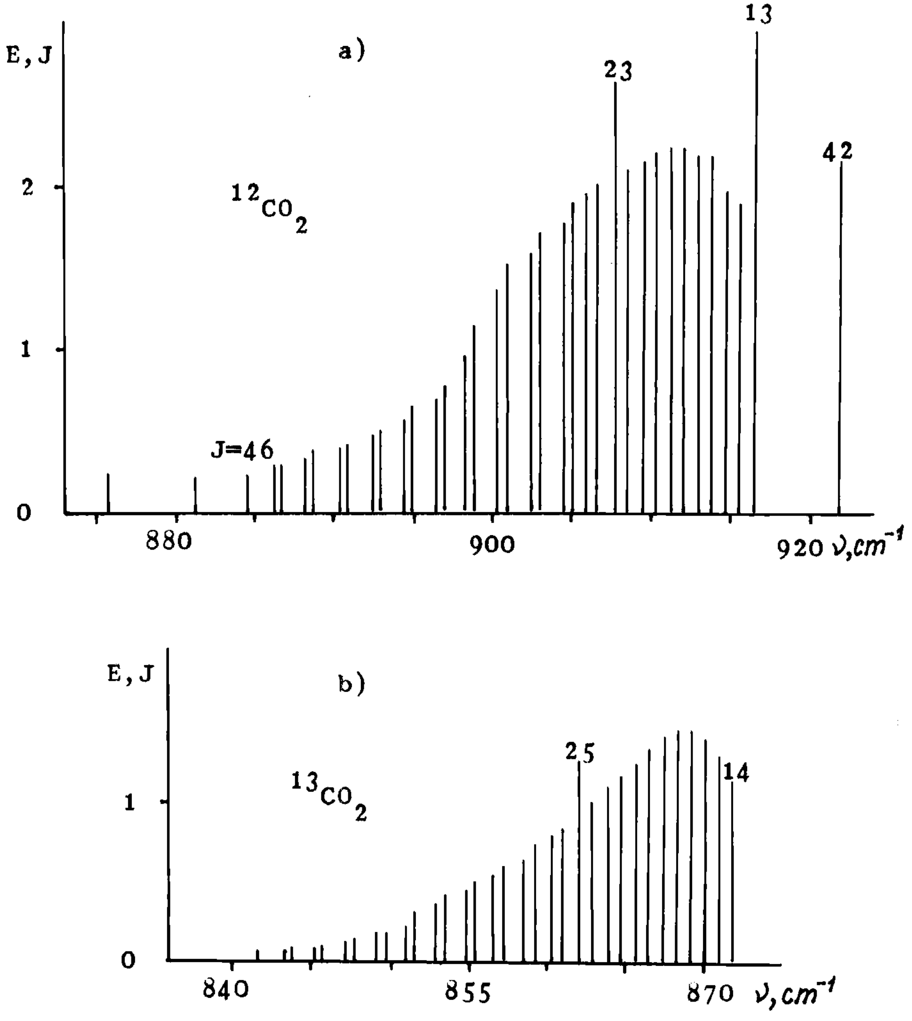

Fig. 1. The output energy distribution on the hot band P-branch for $^{12}CO_2$ and $^{13}CO_2$ molecules

11.9 μm. The strongest line oscillation energy was about 1.5 J. Slightly lower efficiency as compared to that of $^{12}CO_2$ molecule was due to gain reduction because of carbon dioxide mixture use with $^{13}CO_2$ $\sim$69% and $^{12}CO_2$ $\sim$ 31%.

Note, that abnormaly high output energy values for a number of hot band lines for both isotopic species may be explained by their overlapping with the adjacent lines of 00^01-10^00, 10^01-20^00 ... bands.

The use of isotopic $^{13}CO_2$ molecule enables megawatt radiation pulses with frequencies spanning the promising spectral range over 11.4 to 11.9 μm at $\sim$1 cm^{-1} interval to be received for the first time. The radiation with such parameters may be used for the development of ND_3-optical pump laser with oscillation wavelength about 16 μm range.

The spectral range of 12-12.5 μm which is covered by $^{14}CO_2$ molecule hot band lines is of special interest for some applications. In this paper we have not dealt with $^{14}CO_2$ molecule. However, the presented results and analysis of some papers on $^{14}CO_2$ molecule regular band oscillation[6] reveal no principal physical difficulties in obtaining the effective $^{14}CO_2$ molecule hot band oscillation.

The most promising hot band $^{14}CO_2$ laser application may be its radiation use on one of the strong hot band lines ($\nu = 823 \pm 0.5$ cm^{-1}) for uranium isotope separation by multiphoton dissociation of UF_6.[7] To date TEA CO_2 power lasers are well developed and widespread, therefore the proposed source can be easily scaled for commercial uranium isotope separation.

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Received: February 23, 1983
Accepted: March 16, 1983