THE TEMPORAL BEHAVIORS OF MULTILINE OSCILLATION IN A TRANSVERSELY EXCITED ATMOSPHERIC PRESSURE CO_2 LASER WITH AN INTRACAVITY ETALON

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ABSTRACT

Pulse delays among operating lines are observed in a multiline operation transversely excited atmospheric pressure CO_2 laser which has an intracavity germanium etalon. To show the delay effect more precisely, we have replaced the etalon with a 40%/antireflecting coated ZnSe half mirror obtained two laser lines in which the delay can be controlled by a slight tilting of the output coupler. The results show that the individual rotational vibrational transition lines must have almost equal intensities in multiline oscillation in order to obtain high peak power and short pulses.

I. Introduction

The use of a simultaneous two-line operation in a transversely excited atmospheric pressure (TEA) CO_2 laser is very valuable in nonlinear wave mixing[(1)] and two-photon absorption[(2)]. For such applications, two operating laser lines must be tuned independently of each other and synchronized in time. There are some laser schemes satisfying such needs; the bifurcating cavity system[(3)], the dual cavity hydrid system[(4)], and the three cavity mirror system[(5)]. In such systems, there are variable delays between the two simultaneously operating laser lines, which arise from the different gains of the corresponding rotational lines. In addition, multiline oscillations are achieved not only in the hybrid system[(6)] and the injection locking system[(7)], but also through the use of diaphragms[(8)]

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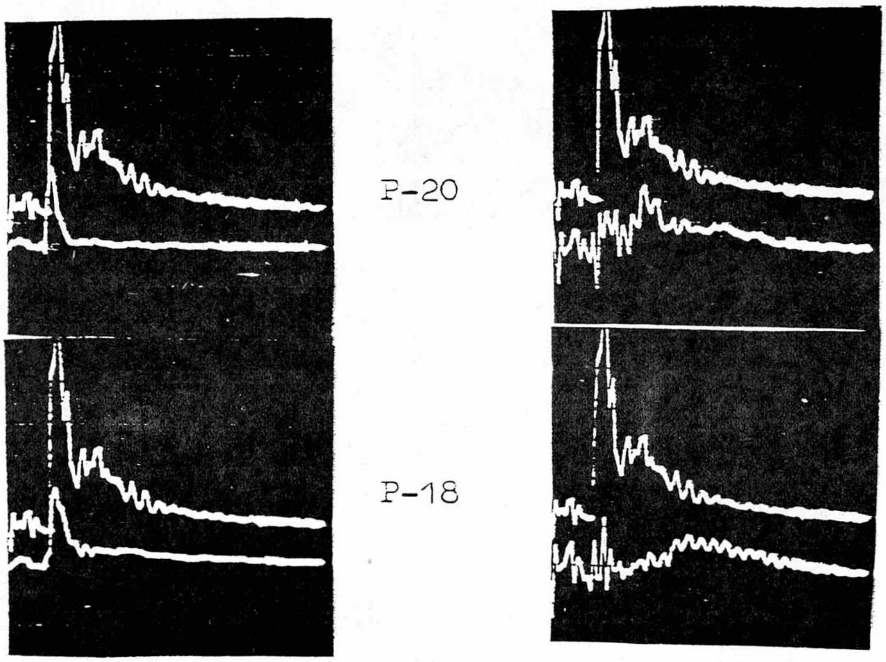
intracavity absorbing gases[9], and an intracavity etalon[10] to extract highly efficient energy from short pulses. There lasers can also be tuned, although the operating laser lines are restricted to a few rotational transitional lines. In these systems, however, the synchronization of the operating lines is not considered, although the pulse delays observed in references (3), (4) and (5), which are caused by the gain competition effect among operating lines, are expected in multiline oscillations.

II. Experimental Apparatus Results andDiscussions

We will report on the pulse delays observed in multiline oscillation laser schemes which have an intracavity etalon and which have three cavity mirrors; a 40%/A.R. (antireflcting coated) half mirror, a 70%/A.R. half mirror, and a total reflector. To conduct this experiment, we used a double discharge TEA CO_2 laser such as the one used in reference (5). The input voltage to the two-stage Marx-Bank generator (26 nF/stage) was set to 17 KV. The laser gas mixture was introduced into the cavity as the ratio of $CO_2:N_2:He=2:1:10$. Operating laser lines wer measured using a CO_2 spectrum analyzer (Opt. Eng). The pulse shapes were monitored by the use of a photon drag detector (Rofin) and a Tektronix 468 storage oscilloscope.

The laser with a germanium intracavity etalon produces simultaneously operating multilines. To obtain variable multiline oscillations, the etalon or the half mirror was tilted slightly. We obtained several laser lines at the 10.6 μm and 9.4 μm bands as in reference (10). Among them we have selected four simultaneously operating laser lines; 10.6 μm P-18, P-20, P-22, and P-24; and observed the pulse ahape as shown in figure (1). The total pulse had a long pulse duration. We separated the laser output to the individual laser lines by using a CO_2 spectrum analyzer and observed each pulse shape. The individual pulses had some delays between operating lines. P-18 and P-20, which have high intensity, emerged first, P-22 which has the lower intensity emerged some time later, and P-24 which has the lowest power emerged last. None of these pulses had as long a pulse duration as the total pulse shape. This result is caused by the gain competition effect among the operating lines. We also obtained this phenomenon at other multiline oscillations in this laser scheme.



P-20

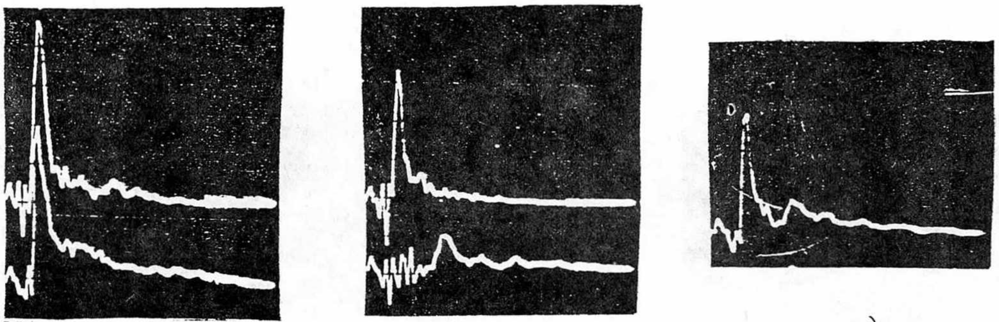
P-18

P-22

P-24

Figure (1) The pulse shapes of multiline oscillation with 4 laser lines with a Ge etalon. Upper traces are total pulse shapes and the lower traces are individual lines as indicated at the left. Sweep time 0.5 μsec/div

To observe the pulse delay more precisely, we reformed the laser with a 40%/A.R. ZnSe half mirror instead of the germanium etalon. The laser produced some multiline oscillations which were in some combinanions of 10.6 m R-18, P-16, P-18, P-20, P-22 and P-24, by slightly tilting the output couplers. We selected simultaneously operating P-18 and P-20 laser lines. A slight tilting of the half mirrors also controlled the intensity ratio between these two lines without altering the operating lines.



a) b) c)

Figure (2) The pulse delays in two-line operation with an additional 40%/ A.R. ZnSe half mirror. The two lines have a) almost equal intensities and b) different intensities. Upper traces are P-20 and lower traces are P-18. c) is the total shape of b). Sweep time 0.5 μsec/div

The output pulse shapes are given in figure (2). When two lines have almost equal intensities, they are produced simultaneously, as shown in figure (2)-a. When the lines have different intensities, there is a pulse delay between the two laser lines as shown in figure (2)-b, where the line having a higher intensity emerged first.

III. Conclusions

These results show that the operating lines in the multiline oscillations do not emerge simultaneously through the gain competition effect, and the parasitically oscillating weak lines do not contribute to the short pulse laser radiation and high peak power, although there were exceptions[11]. To achieve high intensity at a short pulse laser output, the individual lines must have almost equal intensities to match the time. In this system, the pulase delays between operating lines can also be controlled.

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초 록

공진기 안에 Ge 에탈론을 넣은 TEA CO_2 레이저에서 다중 전이선이 발진할 때 발진전이선 사이에서 시간 지연이 생겼다. 이때 생긴 지연효과를 좀 더 정확히 보기 위해 에탈론 대신 한 쪽은 40 % 반사율을 가지고 또 다른 한 쪽은 투과되도록 코팅된 ZnSe 반반사 거울을 넣었다. 이때 출력거울의 각도를 조금씩 틀어줌에 따라 두 전이선이 발진할 때 발진시간을 조절할 수 있었고 출력의 세기도 조절할 수 있었다. 이 결과는 높은 최대출력과 짧은 레이저 출력시간을 얻기 위해서 다중전이선을 발진시킬 때에는 출력전이선들끼리의 이득경쟁효과가 비슷하여 서로 비슷한 세기의 출력을 가져야만 된다는 것을 보여준다.