ROTATIONAL RELAXATION STUDIES IN CO₂ MOLECULES BY MEANS OF A MULTILINE TEA CO₂ LASER SYSTEM

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Abstract—If a CO₂ laser amplifier is injected by a single-frequency oscillator, the efficiency is limited. A multiline pulsed oscillator has been developed to overcome this limitation.

One of the most serious problems in high-power, short-pulse, 10.6 µm CO₂ laser systems is the efficiency. When the short-pulse (pulse duration ≈ 1 ns) amplification efficiency is compared to the efficiency of normal "long-pulse" (pulse duration ≈ 100 ns) CO₂ amplifying systems, the former is rather poor. As is well-known, energy extraction from a laser amplifier only occurs at the wavelengths which are injected. Therefore, conventional oscillators that usually operate on one transition are limited in their capability to extract energy from an amplifier. For example, at room temperature the population in the J = 19 level of the 001 vibrational band is approx. 7% of the total population in this band. If the injected pulse of a single transition laser is very short, rotational effects can be ignored and the efficiency is about 7% of the "long-pulse" efficiency. It is therefore advantageous to inject the amplifier with a laser pulse that oscillates on many transitions. In the past several methods have been used to construct a multiline oscillator, but they all lack the ability to control the various lines independently.

We developed a controllable multiline laser oscillator with up to six adjacent lines oscillating simultaneously on the P-branch of the 001–100 vibrational transition. These lines are independently adjustable which makes it an ideal oscillator for studying the saturation parameter as a function of the number of rotational lines injected as well as a function of the separation between the lines. The results can provide new information about the collisional processes that accomplish rotational relaxation. This information is expected to be important for efficient short-pulse energy extraction from CO₂ laser amplifiers. The oscillator configuration is shown in Fig. 1. The setup is slightly modified with respect to Ref. (3). The result is a decreased intensity of radiation at the grating, mode-locker and output coupling mirror. With the diaphragms in the dispersed arm adjusted properly, the output pulse has a FWHM of 300 ns and consists of a train of pulses. These pulses have a FWHM of 1.2 ns, as measured with a photon-drag detector and a Tektronix R7912 transient digitizer. The shape of the total output pulse is shown in Fig. 2(a), the corresponding energy spectrum is shown in Fig. 2(b). This spectrum appears to be reproducible.

Fig. 1. Multiline laser configuration.
The spectrum of Fig. 2(b) is the result of one oscillator pulse which was injected in a spectrum analyzer built at our institute. It employs a pyroelectric detector array consisting of 32 elements. The instrument permits operation from P(8) to P(36) in the 001-100 vibrational transition. Figure 3 shows schematically the total setup that will be used to study the saturation parameter as a function of the rotational lines. The double-pass CdTe Pockels cell selects one single nanosecond pulse which is injected in a preamplifier that amplifies the pulse to approx. 100 mJ. The pulse then passes beam-focusing/-expanding optics to control the beam size in the amplifier. A fraction of the pulse is then reflected by a beam-splitter to determine the energy, pulse shape and spectrum of the pulse that is injected into the amplifier. After passing the amplifier, which (as well as all the other laser modules) is of the type described by Ernst, pulse energy and shape are measured again. In this way we have accurate information about the parameters of each input pulse and the amplified output pulse.

The results of the experiments will be discussed in a future publication.

REFERENCES