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Q-SWITCHING OF A CO_2 LASER WITH A SATURATING FILTER BASED ON BORON TRICHLORIDE

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1. We report in this communication the results of experiments aimed at obtaining pulsed generation in a CO_2-N_2-He laser by switching a saturating filter in the resonator. The saturation is produced in gaseous boron trichloride (BCl_3). Introduction into the BCl_3 cell of either small amounts of ammonia or large amounts of helium has made it possible to regulate the relaxation time of the saturating filter.

2. Saturating filters are extensively used to obtain giant Q-switching pulses in solid-state lasers.

Wood and Schwarz [1] were able to Q-switch a CO_2 laser by using the saturation of resonance absorption at 10.6 μ wavelength in gaseous sulfur hexafluoride (SF_6). Since the absorption of the SF_6 in the vicinity of the R lines is much smaller than for the P lines, introduction of a gas-filled cell into the resonator causes the laser, which remains in the continuous generation regime, to change from the P region into the R region. To obtain the giant pulse mode, they used in [1] additional frequency selectrion with the aid of a prism placed in the resonator. The boron trichloride used by us has the advantage that its absorption lines cover simultaneously the P and R regions of the CO_2 lasing.

3. The laser discharge tube was 80 cm long and 2.2 cm in diameter. One of the resonator mirrors was spherical, with radius 500 cm, and the other was plane. The energy was taken from the resonator through an aperture of 0.8 cm diameter. The discharge tube was sealed with plates of NaCl mounted at the Brewster angle. The tube was cooled with running

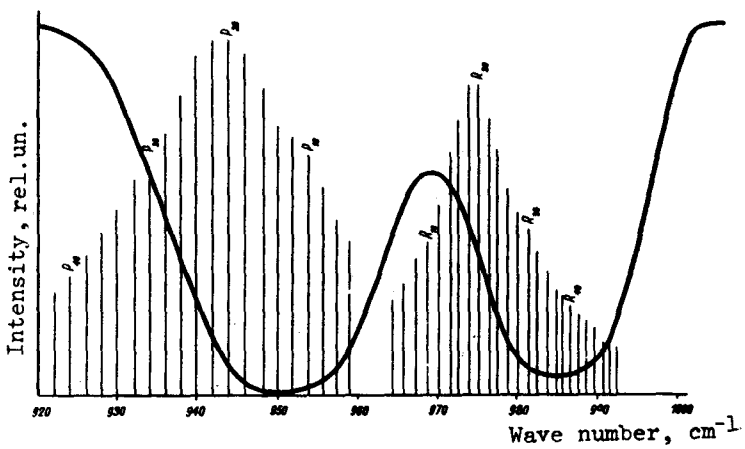

Fig. 1. Absorption lines of the gas $B^{10}Cl_3$ and $B^{11}Cl_3$ at 4 Torr pressure.

water. The CO_2-N_2-He gas mixture was drawn continuously through the discharge tube.

The cell containing the BCl_3 was 20 cm long and 2.2 cm in diameter. The cell was sealed with NaCl plates mounted at the Brewster angle.

The continuous generation power with the cell evacuated was 1 - 2 W.

The generation was registered with a Ge:Au receiver cooled to 77°K and an I0-4 oscilloscope. The time constant of the receiver was on the order of 10 μsec. The absorption and emission spectra were recorded with an IKS-21 spectrograph with resolution ~2 cm^{-1}.

4. The infrared absorption spectrum of gaseous BCl_3 is known [2]. The 10-micron band corresponds to the ν_3 doubly degenerate antisymmetrical valence vibration. Natural boron is a mixture of two stable isotopes, B^{10} (~19%) and B^{11} (~81%). According to the data of [2], the ν_3 vibrations have an energy 956 cm^{-1} in the $B^{11}Cl_3$ molecule, and 995 cm^{-1} in the $B^{10}Cl_3$ molecule, corresponding to the P and R regions of the CO_2 laser generation.

Figure 1 shows the absorption spectrum of BCl_3 together with the P and R lines of the CO_2 laser. Actually the P and R lines agree very well with the absorption bands of the ν_3 vibrations of the molecules $B^{11}Cl_3$ and $B^{10}Cl_3$, respectively. The less active laser R lines correspond to the less abundant isotope B^{10}.

The absorption coefficient of BCl_3 at the center of the line and the line widths are shown in Fig. 2 as functions of the pressure at room temperature. Comparison of the data of Fig. 2 with the gain of the laser discharge for the most active R lines (~10^{-2} cm^{-1}) leads to the conclusion that the cell with the BCl_3 can serve as a saturating filter in a CO_2 laser.

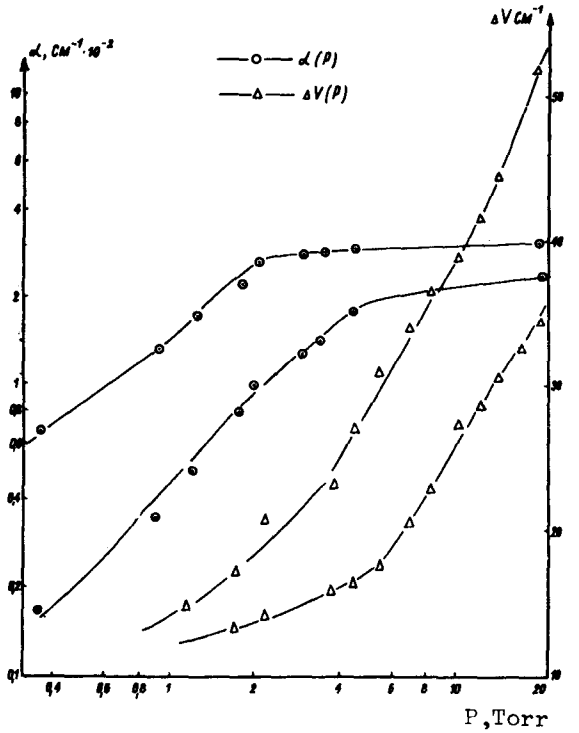

Fig. 2. Absorption coefficient of BCl_3 at the center of the line and line widths vs. pressure at room temperature: ○) α(p), Δ) Δν(p).

5. It has been observed that boron trichloride without impurities does not produce regular periodic generation of giant pulses. Depending on the pressure in the cell with the BCl_3, the laser either ceases to operate or goes over to a regime of quasicontinuous oscillations with an envelope of the relaxation type and with characteristic times 2 - 10 msec. This is evidence that the lifetime of the BCl_3 molecules in the ν_3 state exceeds the lifetime of the upper laser level.

Addition to the BCl_3 cell of air in a 1:1 ratio at a pressure of 1 Torr leads to giant pulses. More stable giant-pulse generation occurs when large amounts of helium are added to the BCl_3. When the BCl_3 is

diluted with helium in a ratio 1:100 and higher, the character of the generation depends weakly on the amount of helium. Thus, the collisions between the BCl_3 molecules and air or helium molecules decrease in a suitable manner the relaxation time of the absorption in the cell.

The best results however were obtained by adding to the BCl_3 very small amounts of ammonia (NH_3). In the pressure range 1 - 7 Torr and in the presence of traces of ammonia in the cell, stable and perfectly regular generation of giant pulses is observed, with repetition periods from 40 to 100 μsec, depending on the pressure, and with an average power 1 - 2 W, equal to the continuous-generation power when the cell is evacuated. Unlike in [1], there is no continuous-generation background in the pulsed regime. When the pressure increases, the pulse repetition frequency decreases, apparently by virtue of the decrease in the losses introduced into the resonator. A pressure of 50 Torr corresponds to a repetition period of 2 msec, but in this case the generation amplitude is much smaller than at ~1 Torr. Filling the cell with pure NH_3 produced no Q-switching.

6. In interpreting the results we must bear in mind that ammonia has a strong absorption line at 950 cm^{-1} [3] and has, unlike BCl_3, a very small relaxation time.

In a cell containing BCl_3 with a slight admixture of NH_3, there occurs apparently a highly effective resonant transfer of vibrational energy by collision of the excited BCl_3 molecules with the unexcited NH_3 molecules, followed by rapid relaxation of the NH_3 molecules to the ground state. The populations of the ammonia molecules in the 950 cm^{-1} transition are not equalized by the laser emission field, since the relaxation time of the NH_3 is very short.

Obviously, in order for such a filter to operate efficiently, the number of NH_3 molecules should be much smaller than that of the BCl_3 molecules, in order that the absorption due to the ammonia not exceed the absorption due to the boron trichloride.

We note that absorption saturation in ammonia can be expected in the case of high-power lasers.

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MASS DIFFERENCE OF K_S^0 AND K_L^0 MESONS, MASS OF W MESON, AND SUM RULES FOR SPECTRAL FUNCTIONS

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A number of recent papers [1-3] have demonstrated the interesting possibility of obtaining convergent results in the calculation of the matrix elements of electromagnetic and weak second-order processes with the aid of sum rules of the spectral functions of the current propagators [4-6].

In particular, Glashow, Schnitzer, and Weinberg [2] obtained a finite expression for the matrix element of the $K_{2\pi}$ decay in second order of weak-interaction theory with inter-