IV. ELECTRODYNAMICS OF MEDIA*

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A. EXPERIMENTS ON ROOM-TEMPERATURE TEA CO LASER

Experiments have been performed on a sealed-off, room-temperature TEA CO laser, with the objective of studying the excitation process in the laser. One startling discovery is that this laser is superradiant.

The discharge length was 76 cm, with 151 1-kΩ resistors, one in series with each pin. A single rod running the length of the tube forms the cathode. The cavity length was 1.4 m, the reflectivity of the curved output mirror was 98%, the radius of the curved mirror was 3 m, and the flat mirror was perfectly reflecting.

Maximum output power was obtained with a mixture of 144 Torr He, 2.2 Torr Xe, and 4.1 Torr CO. Most measurements were performed with this mixture. The addition of xenon was essential to obtain laser operation. It was found that operation without xenon did not produce lasing action, and in fact produced an irreversible change in the gas mixture; later addition of xenon did not lead to lasing.

A typical output pulse and the accompanying current pulse are shown in Fig. IV-1. The peak power was 100 W. Note that the laser pulse occurred unusually early within the current pulse, and that lasing ceased before the current pulse had reached maximum. When the stationary flat mirror was replaced by a rotating flat mirror, in order to check whether the occurrence of the lasing pulse could be shifted by delayed Q-switching, it was found that no such influence was possible.

The lasing pulse was passed through a quarter-meter spectrometer to determine the wavelength of operation. The resolution of the spectrometer did not permit us to pinpoint the frequencies to better than the following CO lines:

Wavelength (μ)	Line
5.067652	P_{6-5} (10)
5.066051	P_{4-3} (22)
5.064895	P_{5-4} (16)
5.064805	P_{7-6} (3)

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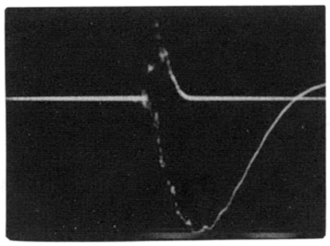
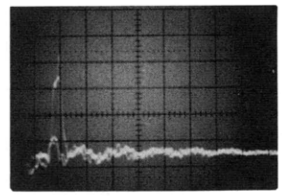
Note that all four lines occur between adjacent vibrational levels. It is likely that the pulse has three or four such vibrational transitions in succession. First of all, the pulse usually shows 3 or 4 peaks (see Fig. IV-1). Further evidence in this direction comes from an experiment in which the flat mirror was replaced by a grating. The pulse shape



200 ns/div.

Fig. IV-1.

Laser and current pulses. Pulses recorded on subsequent shots, estimated timing jitter, 30 ns.



50 ns/div.

Fig. IV-2.

Spontaneous emission pulse. Superposition of 5 pulses.

changed with the grating, and instead of the successive peaks characteristic of laser operation with the mirror, either 2 peaks or one single peak occurred, depending upon the grating orientation. These findings suggest that the three or four peaks noted in operation with a plane mirror represent the occurrence of 3 or 4 successive vibrational lines.[1] The grating strongly selects one of these lines; occurrence of another line presupposes initial operation in the strong line.

A surprising feature of this laser is the very early occurrence of the laser pulse. The delay of the pulse with respect to the leading edge of the current pulse is of the order of 20 ns or less. Such early occurrence of lasing can be explained only if the system has a very high gain; on the basis of this observation, the supposition was that the system might exhibit superradiance. In order to test this hypothesis, we removed the output mirror and looked for detectable radiation. Figure IV-2 shows the radiation pulse observed under these circumstances. The detected peak power was of the order of 100 mW. Such behavior of the system can be explained if the gain of the system is of the order of 60 dB/m.

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References

1. C. K. N. Patel, "Vibrational-Rotational Laser Action in CO," Phys. Rev. 141, 71-81 (1966).