A 0.2 kW Single-Line-Single-Mode Stable CO₂ Laser (*).

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Summary. — The performance of a high-power CO₂ laser for optical pumping is presented. Different operation conditions have been tested: internal and external optics, different reflectors and irides, different gas flow rates and gas circuits. High power, stability and tunability are the main system characteristics. The delivered power in the optimized conditions is 100 W on the 9P(36) line and 200 W on the strongest lines, with a power stability of 99% and a frequency stability within a couple of MHz in some hours.

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1. - Introduction.

Our carbon dioxide laser is a very efficient device. It delivers radiation in the (9.13 + 11.28) μm wavelength range with power levels ranging from about ten watts on the weak lines to about two hundred watts on the strongest lines operating in single mode. Many are the possible utilizations of a CO₂ laser with these characteristics. We will discuss the performance and design of this laser as a resonant optical pump (1). Anyway, we also want to point out that our laser for its features could be suitable as a tool for plasma diagnostics (2).

(*) To speed up publication, the authors of this paper has agreed to not receive the proofs for correction.
IR radiation of carbon dioxide laser is suitable as a coherent pump to excite the molecular rotational-vibrational levels to get laser radiation in far-infrared range. For instance, $^{12}$CH$_3$OH-119 $\mu$m, $^{12}$CH$_3$OH-97 $\mu$m, CH$_2$F$_2$-184 $\mu$m and $^{15}$NH$_3$-153 $\mu$m lines are pumped by CO$_2$ 9P(36), 9R(10), 9R(32) and 10R(18) lines, respectively ($^3$). Therefore carbon dioxide laser devoted to optical pumping has to work on single line and to deliver c.w. high power also on the lower-gain lines. Emission of a single longitudinal and transverse mode is required by resonant coupling. TEM$_{00}$ mode is favourite for optical matching and power needs. Finally laser tunability is necessary to recover the offset $\Delta \nu$ between CO$_2$ line centre and FIR molecule absorption frequency (i.e. about 25 MHz and 36 MHz to pump $^{12}$CH$_3$OH-119 $\mu$m and $^{12}$CH$_3$-97 $\mu$m lines, respectively ($^3$)).

Designing CO$_2$ laser for optical pumping one has to look for the best compromise among the contradictory requirements of high power, tunability and spectral purity. In fact, the output power is proportional to discharge length, but in a too long cavity the modes are very near and the tunability is limited. Moreover, insertion of a diaphragm into the cavity to get TEM$_{00}$ mode operation interferes with power goal (see the appendix).

In this paper we will refer to our c.w. laser with longitudinal gas flow, optimized to operate with a positive offset of ~30 MHz.

2. – System description.

The laser is a 1.9 m long half-symmetrical cavity with a longitudinal discharge ranging from 150 cm (fig. 1A)) set-up, with Brewster window) to 165 cm (fig. 1B)) set-up, without BW). A longer active medium leads to higher output power, but also a reduction of free spectral range (FSR = $c/2L$, where $c$ is the light velocity and $L$ the cavity length). We have chosen $L = 1.9$ m as compromise to get high power and single (transverse and longitudinal) mode operation at the pump frequency.

Piezoelectric ceramic (PZT) is used for the fine tuning of the cavity and an iris is used to favour single-mode operation (see appendix). With a reflector curvature radius of 10 m, the iris diameter must be 10.0 mm.

The plasma tube has a 12 mm bore size and it is cooled by water flowing inside a concentric jacket. Reflector and grating are also water cooled and a small ventilator cools the cathode region. Without optics cooling, a period of half an hour after the laser switch-on is necessary to reach stability and maximum output power.

The power supply (30 kV, 40 mA) is current stabilized.