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# On the Observation of the Λ-Doubling in the O-O UV $N_2$ Laser Band

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*Abstract*—**The spectral composition of the (O-O) $N_2$ UV stimulated band, as the linewidths of the individual stimulated transitions remain unchanged when the nitrogen pressure and the excitation voltage range from 40 to 100 torr and, from the threshold, to 10 kV, respectively, is observed with a laboratory superradiant emitter.**

THIS paper reports that the spectral composition of the (O-O) $N_2$ UV laser band and their linewidths remain unchanged when the nitrogen pressure and the excitation voltage are varied along their respective ranges, which are compatible with the design of the superradiant emitter.

As is well known, pulsed electric field transverse excitation of molecular nitrogen gas lasers refers to, in general, the design of an appropriate array of Blumlein circuit, spark-gap, and discharge tube to obtain the best fulfillment of the threshold excitation conditions for converting electric energy into UV laser radition. A small and simple design of the entire experimental array was proved to be a very efficient device for observing the behavior of both components of the Λ-doublets in the O-O UV laser band of the second positive system. As demonstrated, a double amplitude voltage pulse was observed across the discharge tube electrodes. The charging voltage of the Blumlein circuit was up to 10 kV instead of 30 kV as in previous experiments [1]. The tube was operated at room temperature. The dynamical pressure ranged from 40 to 100 torr. A rear mirror was employed to increase the power of the emitted light pulse. With this mirror the peak power of laser pulses was 1.2 MW.

The O-O UV band of the second positive system was the only one observed, giving a clear indication that the emitter was operating just above the excitation threshold. The spectral analysis of the stimulated radiation and the measurements of spectrographic plates were accomplished by using the same instruments and procedures described in previous reports [1], [2]. The accuracy in wavelength determination was better

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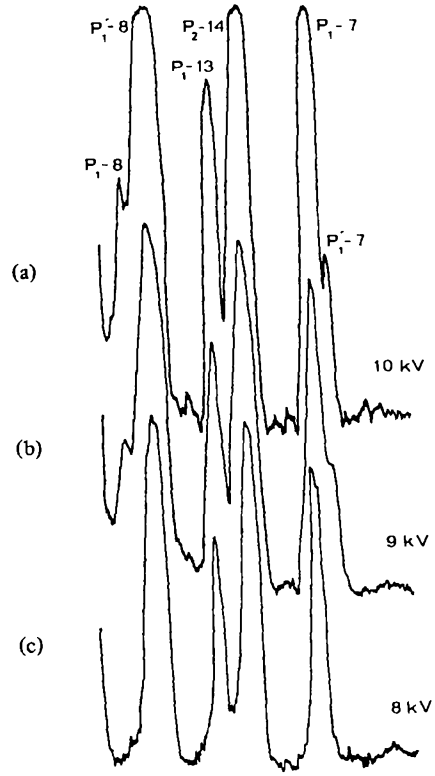


Fig. 1. Changes in microdensitometric traces of the profiles observed in the neighborhood of 337.072 nm, showing the appearance of Λ-doubling as the charging voltage was increased from the threshold to 10 kV. Note the lines $P_1$-13 and $P_2$-14.

than ±0.0008 nm and the resolution achieved was 500.000.

Summarizing the excitation condition voltages on previous spectral observations and on the present one, the results are: 1) Λ-doublets are observed in axial discharges when voltage rises up to 50 kV [2], [3], 2) the strongest alternated symmetry components of the Λ-doublets are observed in transverse discharges of up to 30 kV [1], and 3) Λ-doublets are now observed in transverse discharges of up to 9 kV.

Fig. 1 shows the changes in microdensitometric traces of the profiles observed in the neighborhood of 337.072 nm as the charging voltage was increased from the threshold to 10 kV. It is very easy to identify from the first trace [see Fig. 1(a)] both components of the Λ-doublet corresponding to the lines 337.0726 nm ($P_1$-8) and 337.0714 nm ($P_1'$-8), and 337.0619 nm ($P_1$-7) and 337.0608 nm ($P_1'$-7).

Microdensitometric traces corresponding to spectral plates photographed with transverse excitation, in 1974 [1] and in the present work, show a conspicuous difference. The Λ-doubling contained trace clearly shows the intensity changes in the $P_1$ and $P_1'$ branches together with the alternation due to the influence of the statistical weight of nuclear spin. However, due to the similar intensities of the observed laser lines, their gains become comparable in both branches. The difference in the intensity ratio between the two components of the same Λ-doublets and that theoretically predicted for spontaneous emission, which is equal to 2:1, could be explained by gain saturation that depends on how much higher than the threshold the excitation conditions are, and by nonlinear response of the photographic materials used.

Fig. 2 shows both components of Λ-doublets at $J = 7$ and 8 of the $P_1$ and $P_1'$ transitions observed in transverse excitation.

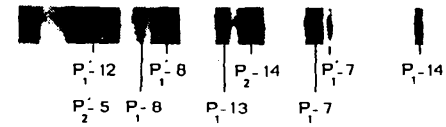


Fig. 2. Positive reproduction of the spectrogram recorded in the neighborhood of 337.072 nm; Λ-doublets are well resolved at $P_1$-7 and $P_1$-8 lines. Note lines $P_1$-13 and $P_2$-14.

In between were recorded the 337.068 nm ($P_1$-13) and 337.066 nm ($P_2$-14) lines. These two lines were reported by Parks *et al.* [4], but they were not observed at all in previous spectral analysis from axial excitation. The actual spectrum contains other features, like the observation of the 336.491 nm ($R_1$-7) line, which was also reported by Parks *et al.*, while it was missed in the spectra of Massone *et al.* [2] and Tocho *et al.* [1]. These characteristics, among the general similarities of both spectra, are evidence suggesting that the excitation conditions in Parks *et al.* [4] and in the present experiments were almost the same. On the other hand, no changes in the present recorded spectra were observed when the gas pressure varied from 40 to 100 torr, as those reported by Petit *et al.* [5].

According to Budó [6], the analytically calculated rotational intensity factor for the electronic transition $C^3\Pi_u$-$B^3\Pi_g$ was estimated from the effective temperature of the nitrogen gas inside the discharge tube [2]. It corresponds to an experimental situation in which the observed spectra of molecular nitrogen are almost at room temperature. This fact shows another similarity between Parks *et al.* [4] and the experiments now reported.

The observed spectral width of all the transitions in the O-O UV laser band, relating to the nitrogen gas temperature, is justified. A linewidth estimation was made taking into account the extremely narrow spectrograph slit used, i.e., 5-10 μm. Varying the nitrogen pressure and the Blumlein charging voltage, the linewidth remains almost unchanged and it always remained the Doppler type, compatible with calculations on spontaneous emission by thermal moving nitrogen molecules at room temperature. Particularly, it explains the impossibility of recording the Λ-doubling in the head of the $P$ and $P_1'$ branches, in spite of the fact that $\Delta\lambda$ assumes the maximum values because of the overlapped transitions corresponding to $J = 9$, 10, and 11. No reduction of the Doppler-broadened linewidths was observed at all as it was reported in [4].

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