# Spectroscopic analysis of the transverse excited $C^3\Pi_u$-$B^3\Pi_g$(0-0) UV laser band of $N_2$ at room temperature: comments

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Received 8 January 1979.
0003-6935/79/111705-01$00.50/0.

Recently Petit *et al.*[1] published a paper devoted to a high-resolution spectroscopy study of the 0–0 laser band in the Second Positive System of molecular nitrogen and explaining the optical gain formation on its different branches. All the results by Petit *et al.*[1] are equivalent to those previously published by Massone *et al.*[2] and are in accordance with theoretical predictions reported by Tocho *et al.*[3] Summarizing, we would comment as follows.

In 1972, Massone *et al.* published a paper[2] devoted to accurate wavelength measurements in the First and Second Positive Systems emitted by a molecular nitrogen pulsed axial laser and to analyze the possible pumping mechanisms in accordance with their experimental results. These results confirmed the general validity of the conclusion of Kaslin and Petrash[4] relating to the influence of temperature on the properties of a pulsed diatomic molecular laser. Such a conclusion, which is more general than that reported previously by Patel,[5] is: The dependence of the gain on $J'$ is the same as the dependence of the intensity on spontaneous emission from the upper level. ($J'$ is the quantum number of the upper level.) The Patel analysis corresponds to vibrational–rotational transitions in diatomic and polyatomic (linear) molecules, while Kaslin and Petrash referred to electronic–vibrational–rotational transitions. Both analyses assumed that the coupling case (a) of Hund is achieved. As is well known, both electronic states in molecular nitrogen, $C^3\Pi_u$ and $B^3\Pi_g$, conform to coupling case (a) for low and moderate $J$ values and to case (b) at high $J$ values. Because of this, Massone *et al.* study the gain dependence as a function of $J$ taking into account gas temperature by using the rotational intensity factor $i$ calculated analytically by Budó[6] for the electronic transition $C^3\Pi_u$–$B^3\Pi_g$ corresponding to the UC Second Positive System. The $i$ Budó factors are tabulated according to the Hund coupling cases. Massone *et al.* presented various diagrams for different branches belonging to the 0–0-UV band at 100 K and 365 K temperatures, and the results were in agreement with their experimental observations.

The observation of both components of the Λ-doublets in all the $P_1$ transitions, and in one of the $P_2$, was the major spectroscopic difference between Massone *et al.*[2] and Parks *et al.*[7] results. But as in the experiments conducted by Massone *et al.* an axial discharge tube was used, while in those by Parks *et al.* a transverse discharge tube was used, it was decided at La Plata to build a superradiant emitter similar to others reported up to 1974,[8–10] in which the nitrogen gas and the discharge tube were cooled with liquid air. The results obtained with this equipment were published by Tocho *et al.*[3] According to the level of excitation of the nitrogen molecules, their spectral analysis of the 0–0 uv band clearly showed that the alternating symmetry Λ-doublets components were observed. This main result led to a definitive solution of the spectral misinterpretation made by Parks *et al.*,[7] which was critically discussed by Massone *et al.*[2] Also, Tocho *et al.*[3] concluded that the comparison between the spectral observations of the "strong Λ-doublets lines," as Dieke and Heath[11] called them, in transverse laser excitation and the full resolved components of the Λ-doublets in axial laser excitation confirms that the Λ-doublets may be observed if the threshold excitation conditions of nitrogen molecules are fulfilled. This statement, of course, clearly indicated that the observation of the Λ-doubling is completely independent of the geometry mode of operation of the discharge tubes.

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