THE PROBABLE IODINE MOLECULAR LASERS
IN THE VIOLET AND ULTRAVIOLET REGIONS

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ABSTRACT

Iodine when excited in the presence of argon shows three band systems in the regions 4420–4000 Å, 3460–3015 Å, and 2785–2731 Å, all of which involve $O_2^+$ ($\pi \sigma^*$) state at 15642 cm$^{-1}$ as the common lower state. It is pointed out in this article that the transitions involving the first two band systems are suitable for laser action as these transitions are very strong and as their common lower state gets efficiently flushed out due to the crossing or touching of a $O_2^-$ repulsive state while a continued high frequency discharge through a mixture of iodine and argon would keep the upper state populated all the time. Tuning of the interferometer system is expected to make this laser action possible in a wide range of frequencies.

INTRODUCTION

The fluorescent$^1$–$^4$ and electrical$^5$–$^8$ excitations of iodine vapour are known to give a discrete band system in the region 6700–5000 Å, and a number of groups of semi-continuous bands (or diffuse bands) in the region 4800–2500 Å. However, the introduction of a foreign gas changes this spectral pattern completely.

Elliott$^9$ reported by fluorescent excitation of a mixture of iodine and nitrogen four band systems in the region 4630–4000 Å, 4321–4041 Å, 3450–3040 Å and 2730–2520 Å. All these band systems except the first one have been later obtained by Waser and Wieland$^{10}$ by exciting a mixture of iodine vapour and argon by high frequency discharge. The first band system obtained by Elliott therefore had been attributed to IN molecule while the other three were attributed to the iodine molecule. Venkateswarlu$^{11}$ later excited the iodine vapour in the presence of argon by transformer and high frequency discharges and obtained the band systems similar to those by Waser and Wieland and in addition also a weak system in the region 2785–2750 Å. These band systems had been reinvestigated a few years ago...
by Verma\textsuperscript{12} by taking the spectra on a 21-feet grating spectrograph and all the systems were well analysed or reanalysed. The ranges of the band systems as extended by Venkateswarlu\textsuperscript{11} and by Verma\textsuperscript{12} are (i) 4420–4000 Å, (ii) 3460–3015 Å, (iii) 2785–2731 Å and (iv) 2730–2486 Å. Of these the first three systems involve the $\sigma_g^2 \pi_u^4 \pi_g^3 \sigma_u \sigma_u^+$ as the common lower state of the system while the fourth one involves the ground state of the molecule as the lower state. We will consider in this paper only the first three systems as they are the only ones of interest from the laser point of view. The upper electronic states of these systems lie at 41411, 45937 and 51847 cm.$^{-1}$ respectively while the common lower state $\sigma_u^+$ is at 15642 cm.$^{-1}$

**PRESENTATION AND DISCUSSION**

The strong discrete band systems in the region 6700–5000 Å which one gets in the emission of iodine vapour without the presence of a foreign gas, is due to a transition from the upper electronic state $\sigma_u^+ (3\pi_u)$ at 15642 cm.$^{-1}$ to the ground state. Venkateswarlu\textsuperscript{11} observed that as argon is introduced the intensity of the visible iodine band system decreases. This band system gets completely quenched above a certain argon pressure and in experiments conducted by him, the band system was absent.

When a foreign gas is introduced the excited molecules in the $\sigma_u^+$ state probably go over to the repulsive $\sigma_u^-$ state\textsuperscript{11} which either touches or crosses the $\sigma_u^+$ state and dissociate into $2^2P_{3/2} + 2^2P_{3/2}$ iodine atoms in the manner suggested by Vanvleck\textsuperscript{13} in magnetic quenching of iodine fluorescence and Turner’s\textsuperscript{14} fluorescence experiments in a mixture of argon and iodine. The absence of the visible band system in emission of iodine in presence of argon therefore suggests that the molecules soon after reaching $\sigma_u^+$ state get immediately flushed out or drained out; and this $\sigma_u^+$ state is the lower state for the band system 4420–4000 Å, 3460–3015 Å and 2785–2730 Å under consideration. This is indeed an ideal criterion for the lower state that one looks for in a laser action. The other criterion that one looks for in a suitable laser action is the intensity of transitions involved. Of the three band systems mentioned, the first two systems 4420–4000 Å and 3460–3015 Å are very intense indicating the use of these transitions for laser action while the band system at 2785–2730 Å is extremely weak and probably need not therefore be further considered at this stage.

Figure 1 shows the potential energy curves of the states under consideration for the iodine molecule. The assignment of electronic terms of various states under consideration are indicated in the figure wherein the assignments for the states marked C, D, F and G are however to be taken