

## Optically pumped molecular iodine mirrorless laser

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### Abstract

*We explore the possibility of molecular iodine as a promising candidate for optical beam combiner systems for a wavelength of 532 nm due to its strong pump absorption and wideness of its visible emission coverage. The preliminary results show that continuous-wave lasing in molecular iodine is achievable without the use of any optical feedback mirrors. We have observed multi-lasing lines in the spectra region from 540 nm to 800 nm for the excitation by the second harmonic wave length of a continuous diode pumped Nd:YAG laser. This system offers significant potential as the optical beam combiner for the high power green lasers.*

**Keywords:** *Optically pumped molecular laser, mirrorless laser, Continuous wave laser*

### 1. Introduction

It has been a great start of the renewing activity in Optically Pumped Gas Lasers (OPMLs) since the demonstration of the of the optically pumped Hollow-core Optical Fiber Gas Laser (HOFGLAS)[1-4]. HOFGLAS reflects a great companion between the gas-filled fiber and the matched pump sources. In addition, HOFGLAS is also meant to stimulate the exploration of the new candidates of the gas media to fulfill the developing avenue in OPMLs.

OPMLs using dimers as gas media have been realized as the multi-wavelength laser sources. Dimer lasers of  $H_2$ ,  $I_2$ ,  $N_2$ ,  $F_2$ ,  $Br_2$ ,  $Na_2$ ,  $S_2$ ,  $Te_2$ ,  $Li_2$  [5] have been demonstrated. In particular, Optically Pumped Iodine lasers (OPIs) have been intensively explored in pulse and continuous-wave (CW) operating modes due to its well overlapped pump absorption to high power lasers. Although pulse mirrorless lasing in OPI has been achieved, the observation of CW mirrorless lasing in OPI has not been reported.

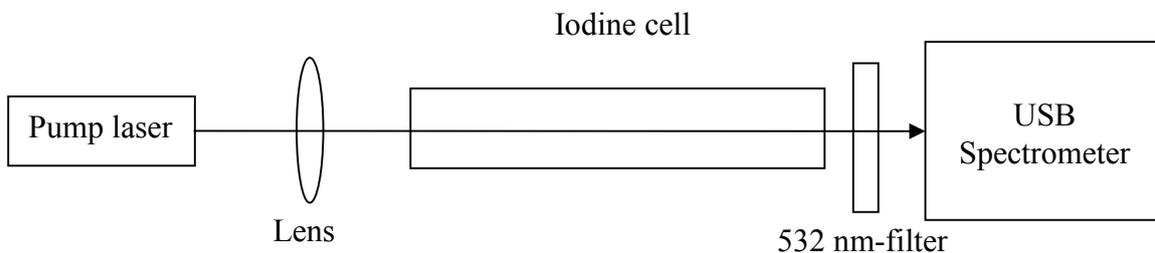
The feasibility study of the CW mirrorless lasing in OPI can benefit to the development of OPMLs and HOFGLAS. CW laser oscillation of  $I_2$  without the use of any feedback mirrors brings the simplicity and compactness to potential applications. The pump absorption of  $I_2$  falling within the commercial wavelength of 532 nm can be taken as a great

advantage.  $I_2$  can be filled inside hollow core fibers therefore this approach means to support the HOFGLAS technology.

In this contribution, the mirrorless stimulated emission from CW optically pumped  $I_2$  laser is reported. Continuous lasing spectra for various  $B^3\Pi_{0^+u} \rightarrow X^1\Sigma_{0^+g}$  are investigated. The threshold of the laser system is discussed.

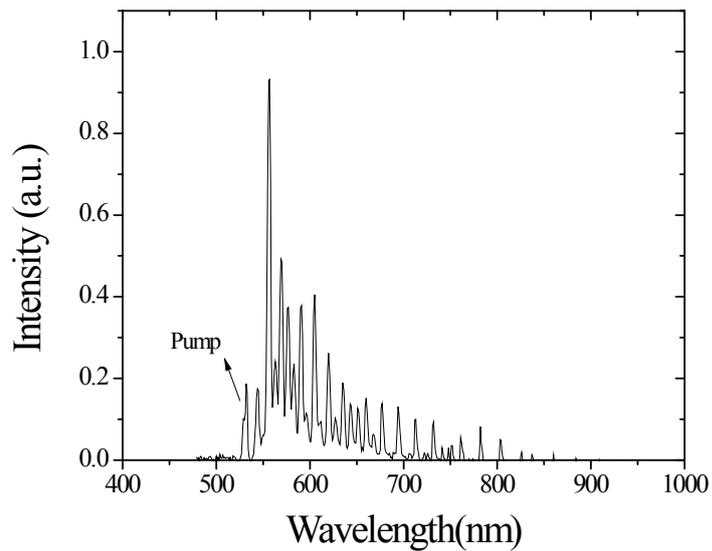
## 2. Methodology and Discussion

Figure 1 shows the set-up of the laser system. The pump laser used in the experiments is an Innolight, model: Prometheus 50 NE. The pump laser, a green laser at 532 nm, is configured by a diode pumped Nd:YAG laser with second harmonic generation. The pump cavity is designed for ultrastable emission. The pump is sent to a lens with the focal length of 20 cm. As a consequence, the focused pump beam is directed into the iodine cell operating at the laboratory temperature (19 C°). It should be remarked that Iodine has an adequate vapor pressure around room temperature. Therefore, there is no need to adjust the cell temperature. The 532 nm-filter performs to eliminate the strong pump beam opening the visibility of the laser spectra in the USB-spectrometer (SM442).



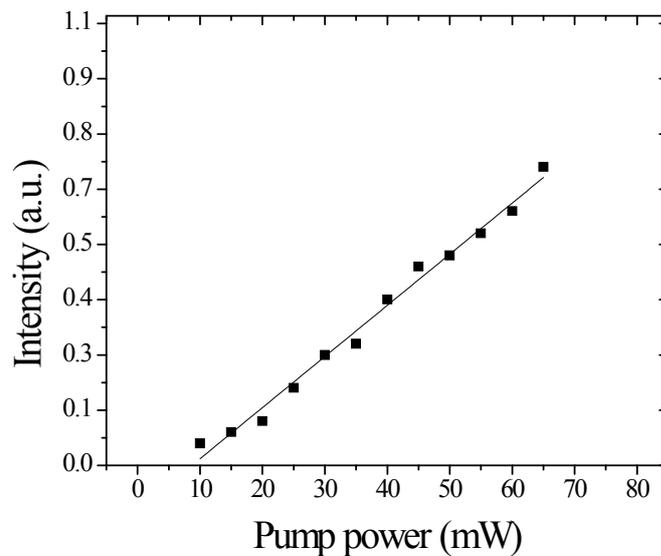
**Figure 1:** Iodine mirrorless laser system

The pump laser power is between 5 and 70 mW. The pump absorption occurs at the transition line R56 (32-0) in the electronic transition  $X^1\Sigma_{0^+g} \rightarrow B^3\Pi_{0^+u}$ . For 40 cm long iodine cell, the pump absorption is measured about 18% at the room temperature. The CW lasing spectra was collected by the USB-spectrometer with the spectra resolution of 5 nm. Figure 2 shows the lasing spectra arise in a range from 544 nm to 800 nm. There are more than observed 20 lasing lines. The laser transitions correspond to the lines between R56 (32-3) to R56 (32-25) in the electronic transition  $B^3\Pi_{0^+u} \rightarrow X^1\Sigma_{0^+g}$ . It is evident that the lasing line R56 (32-4) is the dominated lasing transition. This observation agrees well with the experiment setup and the Frank-Condon factor. However, it should be remarked that the lasing R56 (32-2) should be also occurred but it is eliminated by the necessity of the 532 nm-filter.



**Figure 2:** Iodine lasing spectra in the visible region on  $B^3\Pi_{0^+u} \rightarrow X^1\Sigma_{0^+g}$

The threshold of the CW mirrorless lasing is also examined. The pump power was varied from 10 to 65 mW to investigate the lasing condition. The strongest line, R56 (32-4), was used to benchmark the threshold. Figure 3 provides the result of the threshold measurement.



**Figure 3:** The threshold measurement of the lasing line R56 (32-4).

The threshold of the lasing condition is about 10 mW. This illustrates a significant result in the sense of pumping opportunity. The linearity of the lasing intensity can be used to

determine the scaling law of such as laser. For the future development of this Iodine laser, cavity mirrors can improve the lasing intensity. The experiment also suggests that it may be possible to combine weak green lasers to achieve a single laser beam with high power and high coherence.

### 3. Conclusion

We report the CW Iodine mirrorless laser with a simple configuration. More than 20 lasing lines have been observed. The strongest lasing occurs in the R56 (32-4) transition. The lasing ceased when the pump laser was tuned below 10 mW. This very pump threshold suggests the great possibility of a future beam combiner based on population inversion.

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