N92-13833

Calibration of a Tunable Excimer Laser Using the Optogalvanic Effect

by

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A device for the calibration of a tunable excimer laser is currently under development. The laser provides ultraviolet radiation at three principal wavelengths, 193, 248, and 308 nm and is tunable over a range of 1 nm at each of these wavelengths. The laser is used as a non-intrusive optical probe to excite electronic transitions, and thereby induce fluorescence, of the principal molecules or atoms of interest in supersonic flowfields, both reacting and non-reacting. The fluorescence resulting from the excitation is observed with an intensified camera. Over the range of tunability at the three wavelengths are a number of transitions that can be observed. The intensity of the fluorescence depends in part on the local temperature and density. The nature of this thermodynamic dependence is variable among transitions, thus, requiring identification of the transition under observation. The specific transition excited corresponds directly to the wavelength of the radiation.

The present technique used in this laboratory for transition identification consists of scanning the laser across the range of tunability and observing the fluorescence resulting from various molecular transitions. The distance between transitions can be plotted and compared with a known spectrum. Although this method is valid, there are not always enough transitions under the gain profile to make an accurate determination. Also, accuracy is diminished by the fact that most of these species are molecular and not atomic.

The optogalvanic effect has been suggested as a simple alternative for determining laser wavelength. The optogalvanic effect is induced by illuminating a self-sustained gaseous discharge with radiation that is resonant with the metastable states of the atomic or molecular elements with the discharge. The absorption of a photon changes the probability of ionization of the atom or molecule which changes the electrical properties of the discharge. This change can be observed as an increase or decrease in the conductivity of the discharge. The change in conductivity is known as the optogalvanic effect.

The optogalvanic effect appears to be especially well-suited for laser wavelength calibration. Commercial hollow cathode tubes that are powered by the laser itself are available as discharge sources with various atomic fill gases and electrode materials. Atomic species are desirable since the transition linewidths are very narrow thus providing high resolution. The ideal cell would contain elements that have well-isolated, easily identifiable transitions. When two transitions have been located, a device could be set up to interpolate between transitions and provide a 0-5 volt signal to the operator.

The first phase of an experimental investigation into the use of the optogalvanic effect for laser calibration was initiated this summer. The intent of this phase is to increase the understanding of the behavior of a low-pressure electrical discharge, and to set up a discharge cell and observe the optogalvanic effect using the visible light from a Nd: YAG pumped pulsed dye laser.

A schematic of typical apparatus used to observe the optogalvanic effect is shown in Figure 1.[1] High voltage passes through a current limiting ballast resistor and into one electrode of a hollow cathode lamp or low-pressure discharge. The other electrode is connected to ground. The signal is received through a capacitor which is connected to a boxcar averager. The output from the boxcar is sent to a chart recorder.

First attempts to observe the optogalvanic effect have been made using a normal discharge cell. The cell consists of a glass tube with quartz window mounted on each end through which the laser beam passes. The electrodes consist of circular rings mounted 8 mm apart inside the tube and are oriented so that the beam passes through their center. The beam is focused to a point between the electrodes.

We have not been able to observe the optogalvanic effect to date. It is suspected that spatial positioning of the focal point of the beam is critical. Most of the voltage drop in the cell occurs within a small region near the cathode, and it is likely that the focused beam must be positioned within this area. Future plans include purchasing a commercial hollow cathode lamp in which more accurate positioning of the beam can be accomplished.

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1. Narayanan, K., Ullas, G., and Rai, S. B., Chemical Physics Letters, Vol. 156, No. 1, 1989, 55-60.

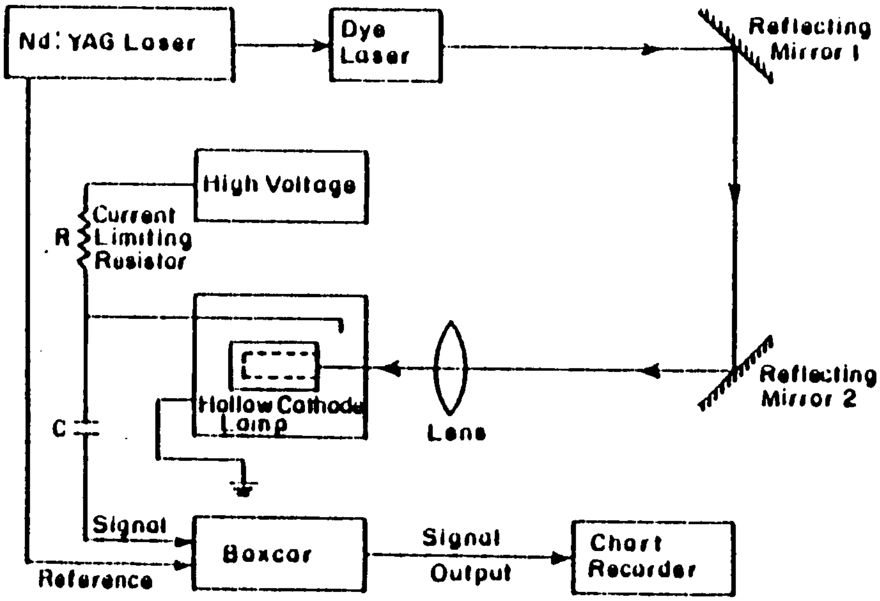

Figure 1. Experimental set-up for optogalvanic effect.