

Development of a Laser Induced Fluorescence (LIF) System with a Tunable Diode Laser

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1. Introduction

The Laser Induced Fluorescence (LIF) is known as one of the most powerful techniques for measurements of ion velocity distribution function (IVDF) and ion temperature by means of Doppler broadening and Doppler shift. The dye lasers are generally used for LIF system with 611.66 nm (in vac.) for Ar ion, the low power diode laser was also proposed by Severn et al [1] with the wavelength of 664.55 nm and 668.61 nm (in vac.) for Ar ion. Although the diode laser has the disadvantages of low power and small tuning range, it can be used for LIF system at the low temperature plasmas. A tunable diode laser with 668.614 nm of center wavelength and 10 GHz mode hop free tuning region has been used for our LIF system and it can be measured the ion temperature is up to 1 eV. The ion temperature and velocity distribution function have been measured with LaB6 plasma source, which is about 0.23 eV with Ar gas and 2.2 mTorr working pressure.

2. Experimental Set-up

The LaB6 cathode used in Diversified Plasma Simulator (DiPS) consists of a disk-type LaB6 which is indirectly heated by the graphite heater up to 5 kW. The discharge voltage and current are 1-100 V and 1-50 A, respectively. It produced the plasma which has following plasma parameters: density= 10^6 - 10^{14} cm⁻³, electron temperature = 1-10eV, magnetic field = 0-2kG with the working pressure of 1-3 mTorr at diagnostic region and 100 mTorr at source region. [2] This experiment is performed in the 2.2 mTorr of diagnostic pressure, 130 mTorr of source region pressure, 400 G of magnetic field intensity, 18 A and 32 V of discharge current and volatage.

3. Laser Induced Fluorescence (LIF) System

The LIF system is composed of tunable diode laser, iodine cell, optical chopper, mirror assembly and photomultiplier tube (PMT) and this is shown in Fig. 1.

The tunable diode laser with the Littrow external cavity geometry has the following parameters: 0.015 nm (10 GHz) of mode hop free tuning range, <1 MHz of beam line width and 25 mW of working power at 668.61 nm. The wavelength is tuned by controlling the piezo actuator during the experiment. The iodine cell is used for calibration of the laser wavelength during the experiments. Since low power of laser and weak

absorption lines of molecular iodine in the wavelength of LIF scheme, it is hard to get the iodine cell spectrum. We overcome this problem to increase the vapor pressure of iodine from the heating of iodine cell at 90 Celsius degree. The iodine cell spectrum is measured with the NTE 3032 photodiode detector and this is shown in Fig. 2. It is calibrated with WA-1000 wavemeter (Burleigh) and it is similar to one of Keesee et al. [3] The lock-in amplifier and optical chopper are used for increasing the signal to noise ratio.

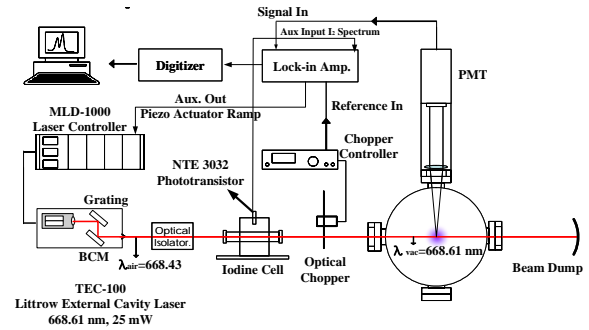


Fig. 1. Schematic diagram of LIF system

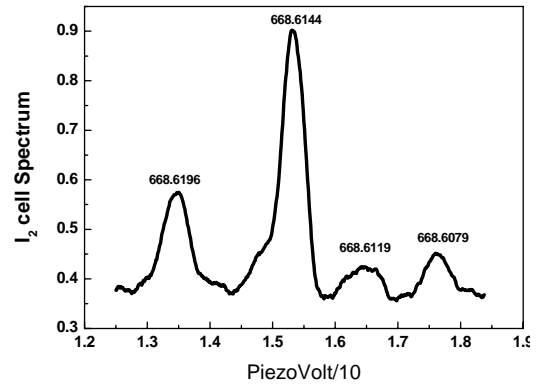


Fig. 2. Measured iodine cell spectrum

4. Results and Analysis

Generally, the LIF intensity shown as

$$I_R(\nu) = \sum_{m=1}^n I_m(\nu_0 - \Delta\nu_m) \exp\left[\frac{-m_i c^2 (\nu - \nu_0 - \Delta\nu_m)^2}{2kT_i \nu_0^2}\right] \quad (1)$$

where, ν_0 , k , m_i , c , T_i and $\Delta\nu_m$ represent the central frequency, Boltzman constant, ion mass, speed of light, ion temperature and the spacings relative to the central frequency of n=6 different Zeeman components. The

Δv_m is generally explained in terms of the central frequency and the magnetic field strength: $\Delta v_m = \pm \epsilon_m v_0 B$. For no magnetic field, the Eq. (1) deduces as below

$$I_R(v) = I(v_0) \exp\left[\frac{-m_i c^2 (v - v_0)^2}{2kT_i v_0^2}\right]. \quad (2)$$

A measured Ar II LIF measurement is shown in Fig 3 and the ion temperature is 0.238 eV.

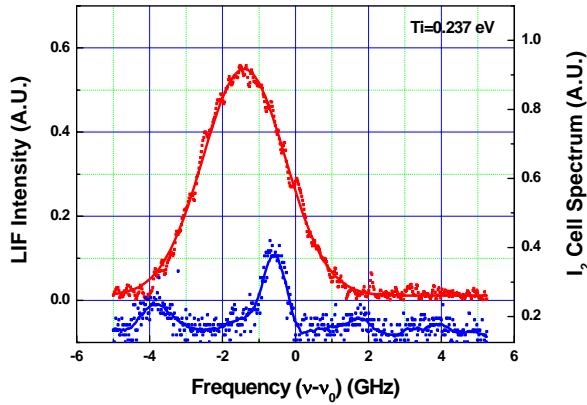


Fig. 3. Ar II LIF signal vs. laser frequency.

5. Conclusions

The LIF system with a tunable diode laser is well constructed for calibration of electric probes. The iodine cell spectrum can be easily got from heating of iodine cell. The measured LIF signal shows the ion temperature as 0.238 eV with good signal to noise ratio.

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