§12. Laser-induced Fluorescence Spectroscopy with Femtosecond Laser Pulses

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Recently, femtosecond laser is put into practical use, and plasma physics has been rapidly changing, accordingly. It is becoming possible to control the atomic state to detect required quantities at extremely high precision.

Laser-induced fluorescence (LIF) method [1] is a powerful tool for changing the population of excited atoms and resonant interaction with tunable diode laser is usually adopted for excitation, however, the experimental procedure is rather complicated to realize the resonance condition.

Electric field of femtosecond laser is comparable or exceeds the Coulomb field of nucleus. It is possible to excite the target atoms with non-resonant manner, which provides simple and convenient procedure independent of experimental condition. We have been investigating the non-resonant excitation of argon atom by femtosecond laser. The fundamental issue of this study is whether or not non-resonant excitation of argon atoms takes place with femtosecond laser. If it is realized, we may develop a new experimental technique to measure the desired quantity with extremely high precision.

Figure 1 shows the experimental setup used in the experiment, where an argon plasma is produced by an RF source (13.56MHz). A femtosecond laser with center frequency 780 nm, pulse duration 100 fs, and output power 140 mW is injected into the plasma to excite the argon atoms. A collection optics with a CCD spectrometer is located above the discharge tube, and the emission spectra with and without femtosecond laser pulse have been measured in the wavelength range between 300nm - 1000nm. To extract the spectrum increment caused by femtosecond laser, the self-emission spectrum from the argon plasma has been subtracted from the raw data. The self-emission spectrum has been obtained by blocking the laser beam and measuring the emission intensity from the plasma.

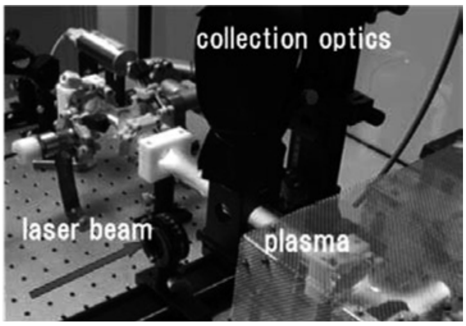

Fig.1 Experimental setup used in the experiment.

Figure 2 shows the increment of spectrum intensity induced by femtsecond laser. Several emission lines form the neutral argon atom have been detected. These lines come from the excited levels of neutral argon atom lying in energy levels between 11eV- 13eV. This result means that the femtosecond laser produces excited atoms in non-resonant manner, which will be utilize to develop a new LIF scheme.

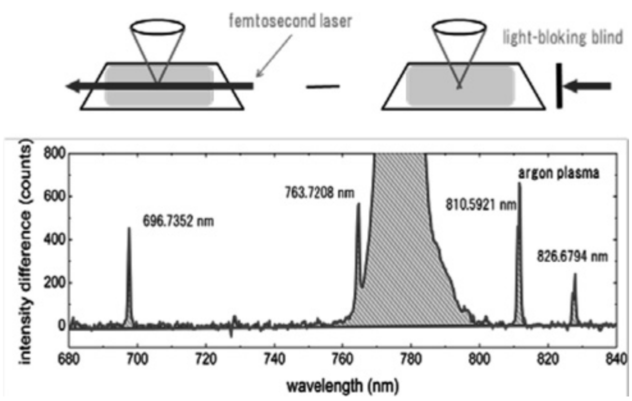

Fig.2 Spectrum increment caused by femtosecond laser pulses. Scattered light from the femtosecond laser is overwritten (760-800 nm)

We have demonstrated non-resonant excitation of argon atoms with femtosecond laser. It is still left for future study to examine the controllability of desired energy level.

1. Aramaki M. et. al. Rev. Sci. Instrum. **80**(2009) 053505-1 – 4.