

§7. Laser-induced Fluorescence (LIF), Spectroscopy with an Aid of Femtosecond Laser

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It has been attracting much attention to control atomic states by using a femtosecond laser pulses. The electric field intensity of femtosecond laser is so strong that level of atomic state (excited level) may be changed by non-resonant interaction with femtosecond laser pulses. This mechanism saves a lot of experimental procedures compared with conventional LIF method [1,2]. We have experimentally demonstrated that a femtosecond laser pulse with an intensity of the order of 10^6 W/cm² can produces excited states of argon atoms. The intensity level in the present experiment is 3 order of magnitude weaker than that used in the tunneling ionization. We propose a new laser fluorescence spectroscopy scheme, in which the target (excited) atoms for LIF are produced by non-resonant interaction with femtosecond laser.

In the experiments in 2012, we have demonstrated that the excited atoms is generated by the femtosecond laser pulses. In 2013, we have made experiments on whether or not the generated atoms can be measured by LIF spectroscopy. To carry out the experiments, we have constructed multi-laser beam system, where the primary pulses(femtosecond laser) generated the excited atom, and the secondary laser measures them by LIF method.

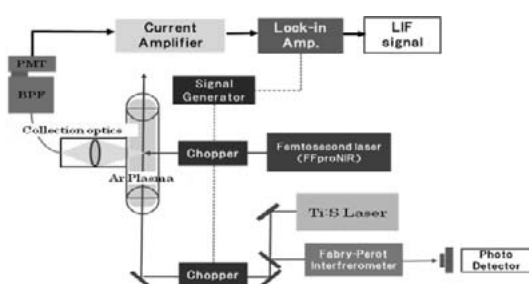


Fig.1 LIF system with an aid of femtosecond laser

Figure 1 shows the optics setup used in the experiment, in which an argon plasma is produced by an RF source (13.56MHz) in a glass discharge tube, and femtosecond laser with 70fs pulse duration, 140 mW

output is injected from the side wall. A collection optics with a photo multiplier tube is located above the discharge tube. The LIF spectrum has been obtained by tuning the wavelength of a Ti:S laser. To improve the S/N ratio of the LIF signal, the Ti:S output is modulated, and the LIF signal has been detected by a lock-in amplifier.

Figure 2 shows the measured LIF spectrum (velocity distribution function). The lower trace is for the case without the femtosecond laser, and the upper trace with a femtosecond laser. As seen in the figure, there is an increase in LIF signal corresponding to the increment of emission spectrum. This result means that the excited atoms generated by femtosecond laser pulse may be detected by LIF spectroscopy, and the new LIF scheme with femtosecond laser pulses is utilize for laser spectroscopy. It is worth pointing out that the new LIF

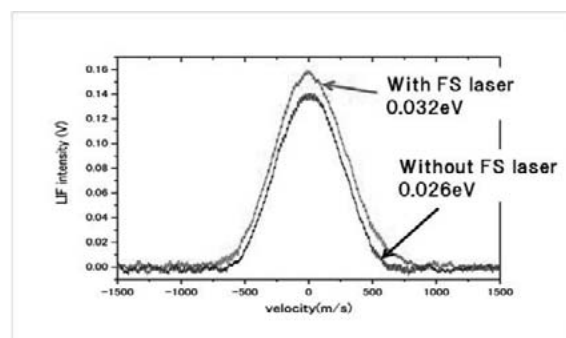


Fig.2 LIF spectrum with an aid of femtosecond laser

scheme will become a powerful tool for c next generation experiment, in which atomic states are controlled.

We have demonstrated non-resonant excitation of argon atoms with femtosecond laser pulses. We are now possible to put a “marker” on a specified atoms. This method will become a powerful tool for next generation plasma physics.

1. Aramaki M. et. al. Rev. Sci. Instrum. **80**(2009) 053505-1 – 4.
2. Ogiwara K. at. al. , Jpn. J. Appl. Phys. **50**(2011) 036101