Development of far ultraviolet light source using laser-produced plasma

S. Tamaki,[1] S. Igawa,[1] H. Ohnishi,[1] Y. Shiina,[1] Y. Nakano, [1]

[1]*Department of Physics, Rikkyo University, Japan*

In the photodissociation region of interstellar space, photoionization, dissociation, and isomerization occur due to the far-ultraviolet light (100-200 nm) from stars. Our goal is to quantitatively understand the reaction dynamics and measure rate constants. Laser-produced plasmas are expected to be a compact FUV light source. We have obtained emission spectra from plasmas of four different metal targets (Al, Fe, Cu, and Inconel (Ni/Cr/Fe)), which show characteristic profiles in the wavelength range 100-200 nm. From the intensity ratios of the obtained spectra, the electron temperature of the plasma was estimated to be 6.4 eV by using the Boltzmann Plot method. The obtained emission spectra were also compared with spectral simulations (Fig.1). In addition, a dedicated off-axis parabolic mirror was developed to collimate the light emitted from the plasma and incident on the monochromator. As a result, the FUV light intensity detected after passing through the monochromator was about 10^7 photons/pulse, an amplification of about 35 times (Fig.2). We plan to experimentally study the interaction of FUV light with polycyclic aromatic hydrocarbons (PAHs), which have few data on photoionization cross sections and reaction branching ratios among molecules in the photodissociation region, PAH molecules have high vapor pressure, and we are currently developing a mechanism to vaporize and pulse PAH molecules. We have also developed a mechanism for discharging the pulsed gas to induce a gas-phase reaction. The reaction routes that occur in this discharge are of interest for astrochemistry as possible growth pathways for PAHs [2]. In this presentation, we will report on the comparison of emission spectra obtained from the four targets with simulations, as well as the specifications of the developed off-axis parabolic mirror and future prospects.

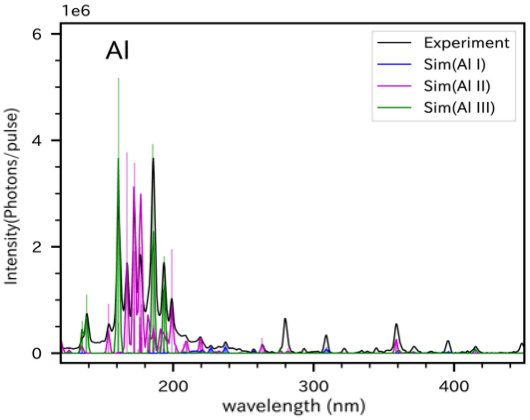

Fig1. Emission spectrum and simulation of Al [1]

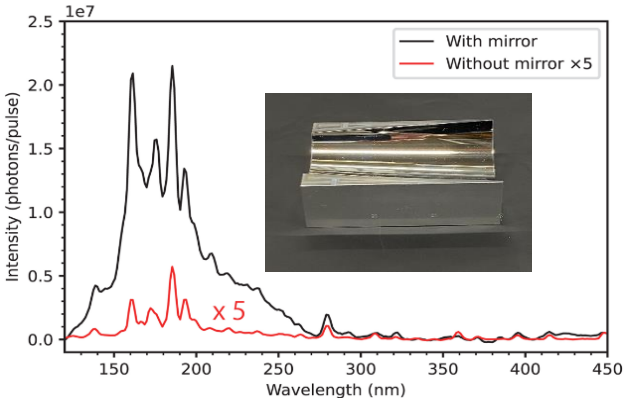

Fig2. Spectrum change by mirror [1]
Spectra from plasma produced by irradiating an Al target with a 532 nm pulsed laser

References

[1] H. Ohnishi, S. Tamaki, Y. Shiina, Y. Nakano; Generation of collimated far-ultraviolet (FUV) light using the laser-produced metal plasma. J. Appl. Phys. 134, 013103 (2023)

[2] Lemmens, A.K., Rap, D.B., Thunnissen, J.M.M. et al. Polycyclic aromatic hydrocarbon formation chemistry in a plasma jet revealed by IR-UV action spectroscopy. Nat Commun 11, 269 (2020).