§11. Wideband High-resolution Spectroscopy of Metallic Pellet Ablation Plasmas in LHD

Shikama, T., Hasuo, M., Fujii, K., Shinohara, M., Nakai, Y. (Dept. Mech. Eng. Sci., Kyoto Univ.), Goto, M., Morita, S.

Pellets containing various elements, for example, carbon, aluminum, titanium, tungsten and so on, have been injected into the Large Helical Device (LHD) for the purposes of studying the dependence of transport coefficients on the impurity nuclear charge, pellet ablation mechanism, and atomic processes in the ablation cloud. A pellet plunged into the plasma is immediately ablated due to heat flux from the plasma. A high density plasma called ablation cloud forms in the vicinity of the pellet, which emits many atomic and ionic emissions. For spectroscopic studies of the emissions, low-resolution wideband spectra containing many emission lines have been measured for hydrogen, carbon and aluminum pellets.[1,2] From such measurements, the population distribution of excited levels of atoms or ions in the ablation cloud has been investigated, and plasma parameters such as electron temperature, neutral atom density and ion density have been estimated. On the other hand, high-resolution narrowband spectra of the emission lines have been measured for carbon pellets, and the electron density of the cloud has been estimated from the Stark broadening.[2]

In this work, we use an echelle spectrometer to perform wideband and high-resolution spectroscopic measurements at one time. The spectrometer enables us to increase the efficiency of spectra acquisition and reduce uncertainty in the spectra associated with the reproducibility of the discharges. In particular, we focus on the identification of the emission lines from tungsten atoms and ions.

Details of the eschelle spectrometer can be found elsewhere.[3] In the present work, we equip two optical fiber channels by installing an additional optical system at the entrance of the spectrometer. We use the two channels for the measurements of the π and σ polarization components of the emission with the Zeeman splitting. We can then distinguish the electric and magnetic dipole transitions from the splitting pattern. The latter originates from highly charged ions.

We use a tungsten wire pellet covered with a plastic tube composed of carbon and hydrogen. The pellet is injected horizontally into the plasma from an outer port of the LHD (1-O port). The line of sight and pellet trajectory are on the same poloidal section, and they intersect at the calculated position of the pellet deposition. We place a polarization separating optical system,[4] which consists of two objective lenses and Glan-Taylor prisms, in front of the viewing port and align the ordinary and extraordinary axes along, respectively, the parallel and perpendicular to the magnetic field direction at the intersection of the line of sight and pellet trajectory. Since the angle from the magnetic field to the line of sight is nearly perpendicular at the intersection, the ordinary and extraordinary light corresponds to the π and σ components of the emission, respectively.

The observed spectra are shown in Fig.1(a). It is noted that the intensity is shown in a logarithmic scale. The expanded spectra in a wavelength range 470-480 nm are shown in Fig.1(b). We identify 253 WI, 126 WII, and 26 WIII lines within the observed wavelength range 390-770 nm based on the NIST database. We also find 98 unidentified lines. Some of the unidentified lines show different Zeeman splitting pattern from that of the electric dipole radiation as shown in Fig.2.

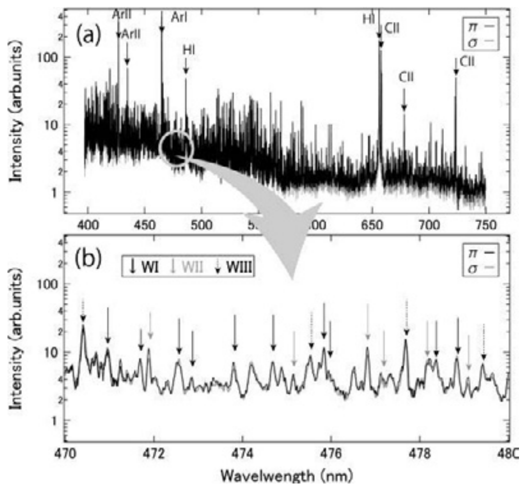

Fig. 1. Polarization resolved emission spectra of tungsten pellet ablation cloud.

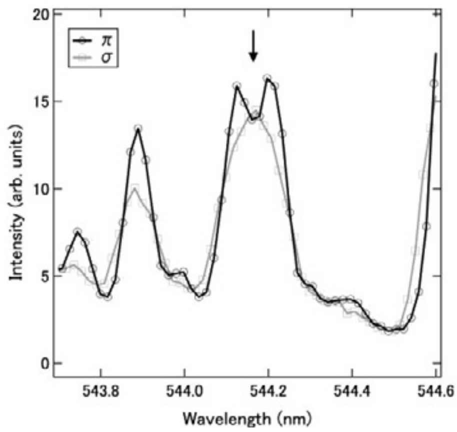

Fig. 2. Emission line showing different Zeeman splitting pattern from that of the electric dipole radiation.

1) Goto, M., Sakamoto, R., and Morita, S.: Plasma Phys.Control.Fusion **49** (2007) 1163.
2) Goto, M., Morita, S., and Koubiti, M.: J.Phys.B:At.Mol.Opt.Phys. **43** (2010) 144023.
3) Hasuo, M., Fujii, K., Shikama, T., Morita, S., Goto, M., and Tanaka, H.: J. Phys.: Conf. Ser. **397** (2012) 012016.
4) Iwamae, A., Hayakawa, M., Atake, M., Fujimoto, T., Goto, M., and Morita, S.: Phys. Plasmas **12** (2005) 042501.