§5. Balmer-α Line Spectrum Measurement of LHD 1/3 Ion Source Plasma

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High concentration of negative hydrogen (H^-) ions in the area near the plasma grid of the LHD one third ion source produces wide variety of characteristic plasma behaviors. The diagnostic system of the one third ion source has been constantly improved and expanded the capability so as to obtain more accurate information on the H^- ion extraction from the source. The LHD one third ion source is currently the only ion source equipped with many plasma diagnostic tools that can deliver the H^- beam with the intensity close to the source used for the actual fusion research test machines.

Taking full advantage of the results obatained by other diagnostics, the correlation between the plasma condition and the line spectrum profile of the plasma light emission from the extraction region are currently being investigated using a 1 m focal length high resolution spectrometer. Due to the fine structure of the hydrogen atom excited to n=3 level, Balmer-α spectrum exhibits a broadening as the monochromator observes the light emission from a low temperature capillary discharge hydrogen plasma. This spectrum together with the spectrum from a HgI line served as the reference to make a fit of the observed spectrum to a Gaussian profile.

Figure 1 shows an example fit to the gaussian distribution of the spectrum obtained from the present spectroscopic system. As shown in the figure, the spectrum accompanies a longer blue wing tail. Fitting the profile to a Gaussian distributuion yields 0.6 eV as the temperature of the n=3 hydrogen atoms. The preliminary measurements reveal some larger shift by tuning the observation angle toward the driver region, or the region in which hot cathodes create high electron temperature plasma to produce highly excited vibrational molecules.

The measured spectrum reflects the projected velocity distribution of hydrogen atoms, and the hydrogen particle transport inside of the ion source. A Monte Carlo simulation code based upon a binary collision approximation, ACAT (Atomic Collisions in Amorphous Targe,) can give information how a surface collision modifies velocity distribution of the hydrogen atoms. Figure 2 shows such change in wavelength spectra depending upon the angle of incidence [1]. The calculated results indicate the possibility that the observed change in spectrum can be attributed to the effect due to surface collision of hydrogen ions.

Source ion source operation parameters like pressure alter the observed Balmar-α spectrum indicating change in the velocity distribution of hydrogen atoms and ions in the plasma. The negative bias voltage to the plasma grid with respect to the plasma potential causes blue shifts, as well as broadening of the Balmer-α line spectra. Precise measurements on how the spectra are correlated to other plasma parameters are being conducted.

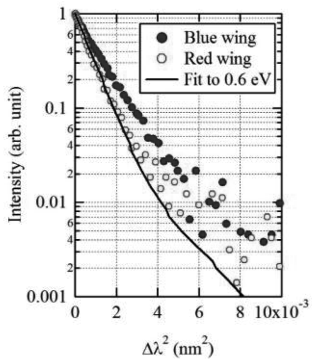

Fig. 1. An example spctrum of Balmer-α line observed in the extraction region plasma of the LHD 1/3 ion source.

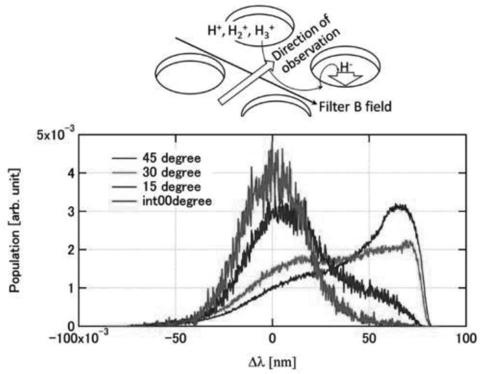

Fig. 2. Wavelength broadening and shift of the Balmer-α line spectrum radiation due to surface reflection.

[1] M. Wada, K. Doi, M. Kisaki, H. Nakano, M. Nishiura, and K. Tsumori, AIP Conference Proceedings **1655**, 020002 (2015).