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

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Electrical power as high as 50 to 70 kW drives the NIFS-R&D Negative Ion Source (NIFS-RNIS), creating a sizable volume high density plasma comparable to a negative hydrogen (H^-) ion sources for fusion plasma heating experiments. A high resolution optical emission spectrometer serves as the tool to monitor the velocity distribution of hydrogen atoms in the source [1]. The spectrometer data coupled to data obtained from other diagnostics form basis to understand which fundamental processes influence the H^- current intensity extracted from the source.

A mechanical structure can change the line of sight for optical spectrum observation as shown in Fig. 1 so as to detect photon emission from atoms in the source, including thouse reflected at the plasma grid surface. Flow of positive ions from the driver region, and that of negative ions from plasma grid produce flow of hydrogen atoms toward the view port through which an optical fiber connected to the spectrometer observes the source plasma. Optical emission spectra have shown a characteristic shift of the blue wing edge to further blue, in accordance with the increase of negative bias voltage to the plasma grid with respect to the plasma potential.

Figure 2 shows an example of comparison between the spectra obatined by setting the plasma electrode bias, V_B, set above the plasma potential at 10 V, and by setting it far more negative than the plasma potential, V_B=-10 V. The spectra after they are normalized do not exhibit substantial shift in the red wing edge suggesting the absence of flow componet away from the observation view port; namely, the main component of the plasma flow toward the drection indicated in Fig. 1. When the difference between the two normalized spectra is plotted as the function of wavelength, the peak shifts toward the blue side by 0.04 nm corresponding to about 2 eV energy of atomic hydrogen flow velocity.

The plasma potential structure in front of the plasma grid measured by a Langmuir probe indicates H^- ion acceleration corresponding to the plasma grid bias voltage. Filter magnetic field bends these H- ions to forma flow in the direction parallel to the plasma grid. Flow measurements by an electrostatic probe array confirms the presence of ion flow in the extraction region of the ion source.

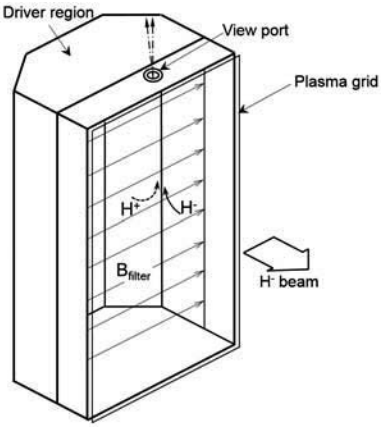

Fig. 1. A schmatic drawing of the experimental set up of the LHD-RNIS showing the direction of flow of hydrogen ions.

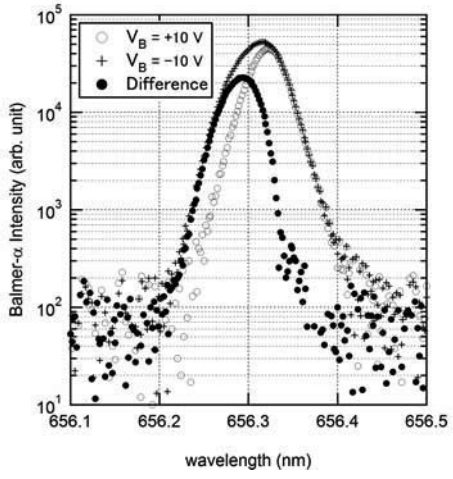

Fig. 2. Wavelength broadening and shift of the Balmer-α line spectrum radiation for two bias voltages to the plasma gird: +10 V and -10 V. Also plotted is the difference between the two spectra.

[1] M. Wada, K. Doi, M. Kisaki, H. Nakano, M. Nishiura, and K. Tsumori, AIP Conference Proceedings **1655**, 020002 (2015).
[2] M. Wada, T. Kenmotsu, Kisaki, H. Nakano, M. Nishiura, and K. Tsumori, Rev. Sci. Instrum. **87**, 02B107 (2016).
[3] K. Tsumori et al., Rev. Sci. Insrum. 87, 02B936 (2016).