§4. Study of Distribution of H_α Reduction and H^- Behavior in the Extraction Region in Hydrogen Negative Ion Source for NBI

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Understanding of hydrogen negative hydrogen ion (H^-) behavior near the production surface, where is called extraction region, is the important issue to maintain high power negative ion beam in a hydrogen negative ion source for a neutral beam injector (NBI). We had observed significant increasing of H^- density owing to the surface production of H^- ions after the Cs seeding in an arc discharge type hydrogen negative ion source for NBI in LHD. These negative ions in extraction region decreases by negative extraction voltage between an extraction grid (EG) and a plasma grid (PG), and extracted ions form beam shape in the the accelerator. Similar signal reduction also appeared on hydrogen Balmer-α spectrum (H_α), because the the mutual neutralization between H^- and H^+ ions is the dominant excitation process in the extraction region with the optimal Cs condition in arc discharge source. I installed the imaging diagnostic to obtain the reduction distribution of H^- ions in the hydrogen negative ion sure in NIFS. Reduction distribution of H_α emission were clearly observed as shown in Figure 1 [1)]. Such findings have contributed to the high performance and safety NBI operation in the Large Helical Device (LHD).

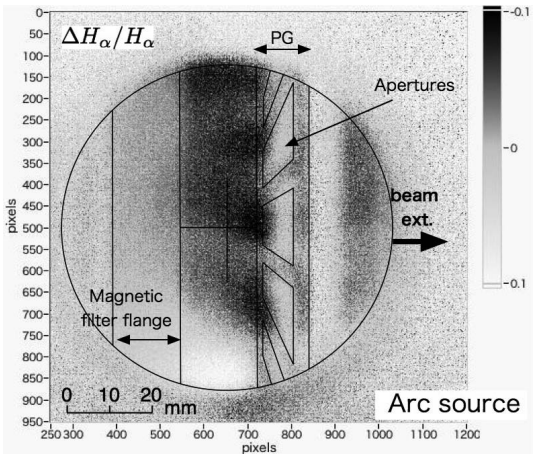

Fig. 1: Distribution of H_α reduction normalized by H_α intensity during beam extraction in arc discharge negative hydrogen ion source in NIFS.

On the other hand, large scale negative hydrogen ion source based on RF discharge is constructing for International Thermonuclear Experimental Reactor (ITER) . Optimization of RF source performance and variable operation outputs have been carried out from a half size H^- source in ELISE test facility in Max-Planck-Institut für Plasmaphysik (IPP) Garching [2)]. Behavior of negative hydrogen ion in extraction region of RF source is also important knowledge for production of high power beam and optimization of beam divergence. I visited IPP Garching from 5th May to 30th November 2015 to install a spectrally selective imaging system in the RF negative ion source in ELISE, which diagnostic system consists of a GigE vision camera with Gigabit Ethernet connection and a narrow optical bandpass filter. Although the PG surface can not be seen covered by a bias plate (BP), the distribution of H_α emission close to the BP has been clearly observed as shown in Figure 2. The time trace of H_α intensity observed by imaging diagnostic is consistent with that observed by optical emission spectroscopy located at the opposite side viewing port. Signal reduction of H_α emission appeared on both diagnostics. Reduction area is widely distributed in the extraction region during the long discharge operation, which reduction behavior is similar to the distributions which is measured in arc discharge source in NIFS which adopted different method on magnetic filter. H^- ions produced by the surface conversion effect widely distributed in the extraction region in the extraction region of both negative hydrogen ion sources, and mechanism of beam extraction is likely to be common. Therefore, these negative ions are considered to be most important source component for production of negative ion beam.

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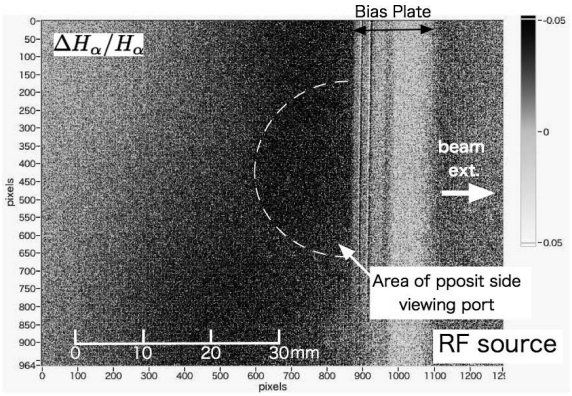

Fig. 2: Distribution of H_α reduction normalized by H_α intensity during beam extraction in RF discharge negative hydrogen ion source for ELISE.

1) K. Ikeda, H. Nakano, K. Tsumori, M. Kisaki, et al., AIP Conference Proceedings **1655**, 040005 (2015).

2) P. Franzen, B. Heinemann, U. Fantz. et al., Fusion Engineering and Design, **88**,12, (2013), pp. 3132-3140