§18. Integrated Modeling of Negative Hydrogen (H-/D-) Ion Production, Extraction and Acceleration in a Large Negative Ion Source for Neutral Beam Injection System

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In N-NBI (Negative-ion-based Neutral Beam Injector) system for large fusion devices such as LHD, the optimization of 1) negative ion (H^-) production, 2) H^- extraction from the source, and 3) H^- beam acceleration towards the target are the key issues to achieve intense high power N-NBI beam for plasma heating.

Recently, in the NIFS-R&D ion source which is scaled down with a half size of the LHD ones, it has been reported that the Ion-Ion Plasma (IIPL) which mainly consists of H+ and H- ions) is formed in the vicinity of the beam extraction aperture on the plasma grid (PG) under the "surface" H- production case with the Cs-seeding. Moreover, it has been shown the IIPL strongly affects the H- beam extraction from the ion source and the resultant H- beam optics.

In this study, we have developed a 3D3V PIC (Three Dimensional in real space and Three Dimensional in Velocity space Particle in Cell) model to clarify the IIPL formation (Fig.1). The electrostatic potential structure in the extraction region is solved self-consistently with the charged particle dynamics (H+, H^- ion and electron). The electron diffusion across the filter magnetic field has been taken into account by $\tau_{//}/\tau_{\perp}$ model ($\tau_{//}$ and $\tau_{\perp}$ are the electron loss time along the field line and the diffusion time across the filed line, respectively).

Using the 3D3V PIC code, we have done systematic study of the IIPL [2]. In Fig. 2, 2D profiles of the density ratio n_H-/n_e in the extraction region are shown, where n_H- and n_e are H^- ion and electron density, respectively. Moreover, Fig. 2 (a) and (b) are case w/wo electron loss along the filter field line. As seen from Fig. 2, the thickness of the IIPL (n_H-/n_e > 40) is formed in the case with electron loss. This suggests that the mechanism of the IIPL formation is due to the electron loss along the magnetic filter field. For further understanding of control parameters of the IIPL, more detailed comparison with the experimental results is now underway.

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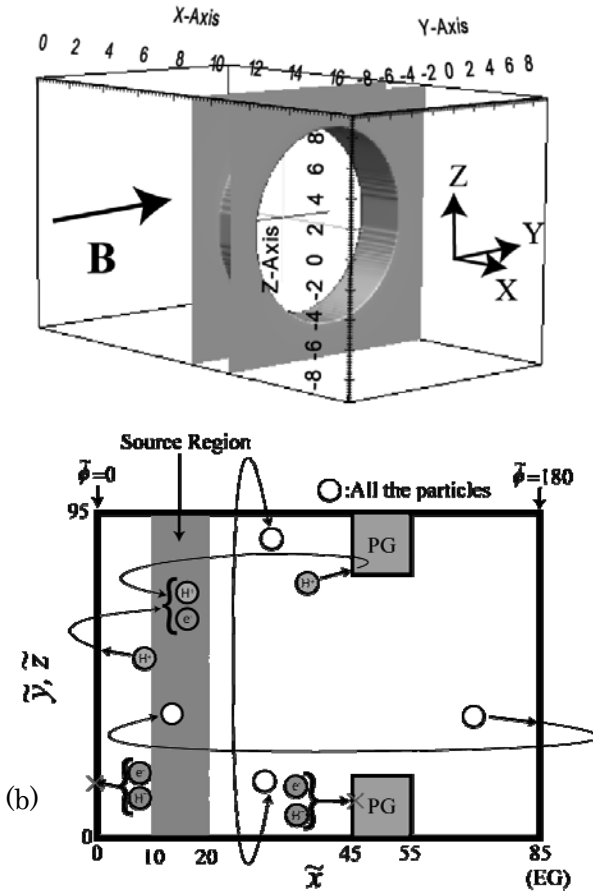

Fig. 1 Schematic viewgraph of the simulation model (a)simulation domain and (b)boundary conditins.

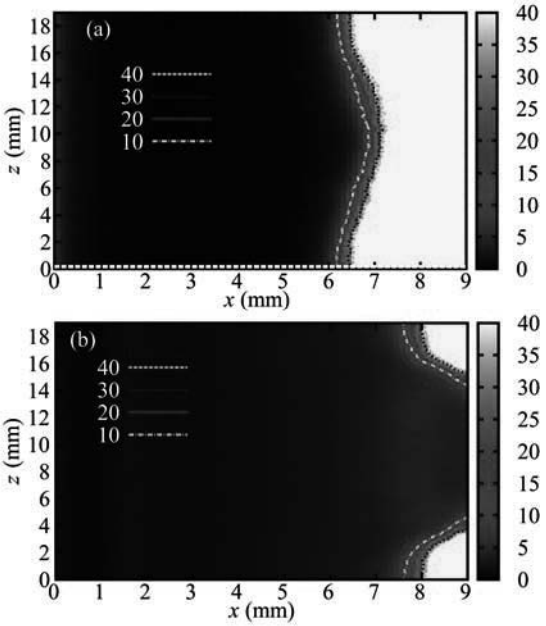

Fig. 2 2D profiles of density ratio n_{H^-}/n_e;
(a)with electron loss (b)w/o electron loss
(cited from Ref.[2])