§11. 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^-/D^-) production, 2) H^-/D^- extraction from the source, and 3) H^-/D^- beam acceleration towards the target are the key R&D items to obtain intense high power N-NBI beam for plasma heating.

For the optimization of the H^-/D^- extraction from the extraction hole, it is indispensable to understand the formation mechanism of the ion emissive surface (so-called plasma meniscus) and its location/shape around the extraction hole. Recently, in the NIFS half-scaled R&D ion source, the following interesting experimental observations have been reported under the strong "surface" H^- production case with the Cs-seeding[1]: 1) Plasma layer almost only with H^+ and H^- ions (i.e., double ion plasma with only few electrons) is formed in front of the PE, and 2) the thickness of the double ion layer is relatively large (at least, it exists between 6.5mm and 12.0mm from the PE by Langmuir probe measurements). These double ion plasma characteristics possibly affect the potential structure and the resultant H^- ion emissive surface.

We have developed the 2D3V PIC (Particle-in Cell) model[2] to analyze the potential structure in the extraction region self-consistently with the charged particle dynamics. The model has been applied to the detailed analysis of extraction region in NIFS half-scaled R&D ion source[3]. The model geometry used in the simulation is shown in Fig.1. As shown in Fig.2 and 3, the initial results brought by the 2D PIC modeling reproduce well the basic and intrinsic characteristics of the double ion plasma observed in the recent experiments with the NIFS-R&D source under the Cs-seeded condition. The results also give a useful understanding of the physical mechanisms which lead to the double ion plasma with poor electrons in the extraction region. It is also shown that the H^- emitting surface, i.e., the plasma meniscus for such double ion plasma is possibly located relatively far from the extraction hole and the PG surface. More detailed and quantitative comparisons with the experiments are being currently underway.

1) K. Tsumori, *et. al.*, *Super CCNB 2010*, Takayama, Gifu, Japan, (2010).
2) S. Kuppel, D.Matsushita, A.Hatayama and M.Bacal, J. Appl. Phys. **109**, 013305(2011).
3) N. Kameyama, *et al*, *"Analysis of the H⁻ ion emissive surface in the extraction region of negative ion sources"*, Rev. Sci. Instrum., to be published.

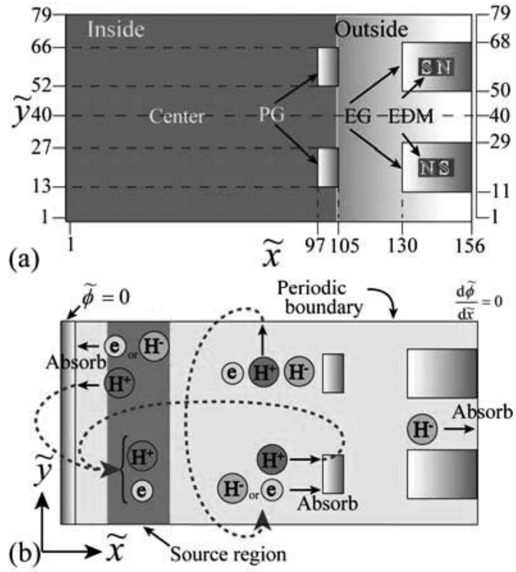

Fig.1 Numerical model for the NIFS half-scaled R&D ion source : (a) The model geometry, (b) Boundary condition used in the simulation.

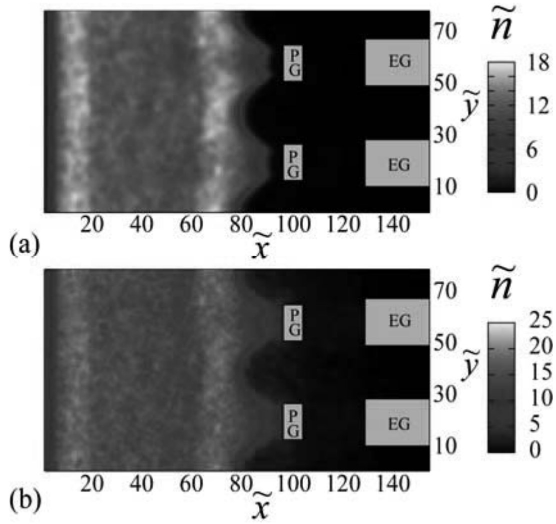

Fig.2 2D density profiles of (a) electrons and (b) positive H^+ ions before beam extraction.

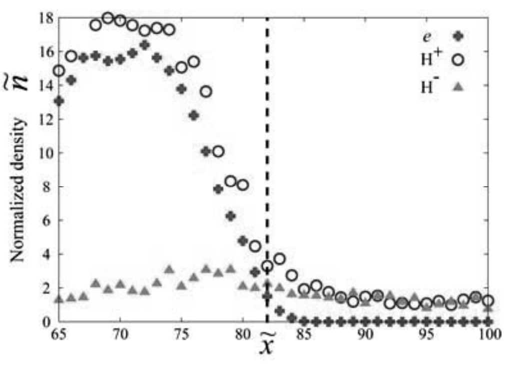

Fig. 3. Density profiles of electrons, H^+ ions, and H^- ions along the extraction axis ($\tilde{y} = 40$) before the beam extraction.