Modeling of Negative Ion Plasma in Hydrogen Negative Ion Sources
- Recent Progress and Open Problems -

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Negative hydrogen (H^-) ions have a potential for a wide range of applications, e.g., for generation of intense neutral beam (NB) for heating magnetically confined fusion plasmas, for intense H^- injection into cyclical accelerators, and for plasma processing, such as for the delaminating of Si wafer on material technology. These applications continuously provide strong impetus for the development of H^- sources with increasing intensities, better beam optics and spatial uniformity.

Recent advances and open problems in modeling of H^- ion sources are reviewed and discussed with some new results. The emphasis is placed on the understanding of basic physics essential for the key R&D issues in the development of large volume H^- ion sources:

- Extraction Physics

The extraction of H^- ions from the source is shown to be significantly improved by a synergetic effect of the "week" transverse magnetic field and the "PG (Plasma Grid) biasing" in the Camembert III experiments[1]. Underlying physics which leads to the significant enhancement of H^- extraction, e.g., the sheath structure near the PG under the presence of negative ions and the weak magnetic field, will be discussed with the recent results by the 1D3V and 2D3V PIC (Particle in Cell) modeling of negative ion sources.

- Large scale transport of H^- ions

In order to obtain more complete understanding of H^- extraction, not only the sheath structure close to the PG discussed above, but also more large scale transport of H^- ions from their birth to the PG is important. Effects of collisions, magnetic field and electric field on the H^- transport are discussed with the recent results by Monte Carlo H^- transport simulations and their comparisons with experiments.

- EEDF and role of dissociated atoms on the surface H^- production

3D Monte Carlo modeling of production and transport processes of H^0 atoms has been done for the analysis of JAEA 10 ampere H^- ion source[2]. The simulation results show that the surface H^- production is enhanced near the high T_e region where the high energy Franck-Condon H^0 atoms are produced. These results suggest the importance of controlling electron energy distribution (EEDF) in order to enhance surface H^- production and to keep the spatial uniformity. Numerical analysis of the EEDF by a new Monte-Carlo code in the multi-cusp arc-dischage source and comparisons with the experiments will be also presented and discussed.

[1] P.Svarnas, *et al.*, Plasma Sources Sci. Technol. **18**(2009)045010.
[2] N.Takado, *et al.*, J.Appl.Phys **103**(2008)053302.