Numerical analysis of electronegative plasma near the extraction grid in negative ion sources

S. Kuppel[1], D. Matsushita[1], A. Hatayama[1], and M. Bacal[2]

[1]*Graduate School of Science and Technology, Keio University, Japan*
[2] *Laboratoire de Physique et Technologie des Plasmas, Ecole Polytechnique, UMR 7648 du CNRS, France*

Using negative hydrogen ion H^- source is a very promising way to obtain the high energy neutral beam required for heating plasmas in the future nuclear fusion reactors. Among other R&D issues (such as spatial uniformity for volume/surface H^- production, global improvement needs concerning H^- production efficiency, etc.), optimization of H^- extraction from the source is a key step for developing negative ion sources as efficient as possible.

This study focuses on extraction physics and aims at clarifying the importance of the plasma grid region in the extraction efficiency, on two different points: First, by highlighting the behavior of surface produced H^- ions (the surface being the plasma grid) under a weak transverse magnetic field, and subsequently by studying more generally the influence of a DC bias potential on the extraction efficiency.

A previous study pointed out that the potential structure near the plasma grid is strongly modified by the presence of a weak transverse magnetic field in the extraction region, and is also depending on the H^- production process used, volume or surface [1]. As a general consequence, extracted (both volume and surface produced) H^- ion current densities are significantly enhanced by the weak transverse magnetic field, and the experiment provided a similar result [2,3]. All above-mentioned simulation results were obtained using particle-in-cell (PIC) method in its 2D3V version [two-dimensional in real space and three-dimensional in velocity space].

In the current study, the previous code is optimized and extended as follows: (1) a detailed analysis of trajectories for all species is implemented in the code outputs, and (2) adjustable DC bias voltage is integrated into the calculation process. Simulation is still in progress, but the results are to be presented according to the following main lines:

(a) Characterizing the influence of the weak transverse magnetic field on the potential structure.

(b) Characterizing the influence of the DC bias voltage on the potential structure, which is expected to be significant, based on the results provided by a preliminary 1D3V PIC code [4].

(c) Highlighting of the relation between the potential structure and particle trajectories, especially extracted H^- ions produced on the plasma grid surface.

(d) Scanning key parameters, such as DC bias voltage amplitude, electron temperature, and surface production rate and area (size, location) in order to compare with experiment [5].

References

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