# SUMMARY OF Ph.D. DISSERTATION

| School | Student Identification Number | SURNAME, Firstname |
|---|---|---|
| **Fundamental Science & Technology** | | **SAKURABAYASHI, Toru** |

Title

## Study of negative ion transport in negative hydrogen ion source


Abstract

Neutral beam injection based on the negative ion source is one of the most effective means for heating nuclear fusion plasma. To generate high current beams of negative ions ( $H^-$ ) and optimize the beam optics, understanding of transport properties of $H^-$ ions is indispensable. The main purpose of this study is to understand the transport properties of $H^-$ ions in negative ion sources. Two numerical simulation models: (a) Monte Carlo (MC) model of negative ion transport and (b) electrostatic particle-in-cell (PIC) model are developed and applied to the analysis of $H^-$ transport in negative ion sources.

Chapter 1 is the introduction. The present status of the study on analysis of negative ion sources is reviewed.

In Chap. 2, the main features of (a) the MC model and (b) the PIC model developed for the analyses of the negative ion transport are described.

In Chap. 3, energy relaxation processes of $H^-$ ions in a tandem type $H^-$ source are discussed using MC model. The kinetic energy of $H^-$ ions is relaxed through Coulomb collision with background plasma which has a low temperature of ~1eV in the negative ion source. As a result, the divergence angle of extracted negative ion beam becomes small. The energy relaxation by Coulomb collision plays an important role of the good beam optics.

In Chap. 4, the MC model is applied to the analysis of the large hybrid multicusp negative ion source, "Camembert Ⅲ". For volume production, pressure dependence on the destruction processes is studied. For surface production, the influence of the birth point of $H^-$ is studied. For volume produced $H^-$ ions, the wall loss is significant at 1 mTorr compared with at 3 mTorr. Therefore $H^-$ ion density becomes small at 1 mTorr compared with at 3 mTorr. For surface produced $H^-$ ions, the $H^-$ ions launched from the sidewall hardly can reach the center of the source due to the trapping the multicusp magnetic field. This indicates the sidewall has not significant effect on $H^-$ current. The upperwall or the plasma grid (PG) around the extraction aperture is shown to contribute to $H^-$ extraction.

In Chap. 5, 6, the effects of a weak transverse magnetic field on $H^-$ extraction in a negative ion source is studied by means of the PIC model. Since electrons are magnetized by the weak magnetic field, more $H^-$ ions arrive instead of electrons in the region close to the PG in order to ensure plasma neutrality. The presence of the weak magnetic field produces important modifications in the positive ion flow, and, as a result, in the structure of the spatial potential which collects $H^-$ ions. In addition, the effects of the electron diffusion on the spatial potential and $H^-$ transport are examined. Although the positive spatial potential is reduced by the effects of the electron diffusion, a relatively small positive potential peak remains at the position closer to the PG. Due to this positive potential peak, the $H^-$ ion density in front of the PG still becomes comparable to that in the case without the electron diffusion.

In Chap. 7, summary and conclusions of this thesis are given.