01aP69

水素負イオン源におけるビームハロ形成機構に関する研究
Study of beam halo formation in negative hydrogen ion sources

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1. Introduction

Negative ion (H^-) based Neutral Beam Injection (N-NBI) system is one of the promising candidates for fusion plasma heating and current drive of magnetic fusion reactors. The requirement of negative ion sources in the N-NBI system is to produce the high beam current density with long pulse [1].

In order to develop such a negative ion source, it is necessary to suppress the beam halo component which is the divergence part of the H^- beam for reducing the heat loads on the acceleration grid in the N-NBI system. Recently, it has been reported that the beam halo formation is due to the curvature of the plasma meniscus which is the ion emissive surface [2-3]. Therefore, the study of the plasma meniscus formation has been required.

In the previous study, it has been shown that the Coulomb collision between H^+ ions and H^- ions in the extraction region is one of the key physics process for the mechanism of the H^- beam extraction [4]. The purpose of this study is to clarify the formation mechanism of the plasma meniscus and resultant beam halo. Especially, the effect of the charge exchange collisions (CXC; $H^- + H \rightarrow H + H^-$) and the Coulomb collisions (CC) between H^+ ions and H^- ions on the beam halo and plasma meniscus formation will be focused on.

2. Simulation Model

We have developed the numerical simulation model for the extraction region in negative ion sources with 3D Particle in Cell (PIC) methods. The detail of this simulation model is described in Ref. [2]. In. Fig. 1, the simulation domain in the present study has been shown. Based on Ref. [5], the magnetic filter and the electron suppression magnetic field are taken into account in the *y* direction and *x-z* plane, respectively.

In the present study, the Coulomb collision between H^+ ions and H^- ions has been taken into account by the Binary Collision Model [6]. Moreover, the CXC ($H^- + H \rightarrow H + H^-$) has been taken into account by the null collision model [7].

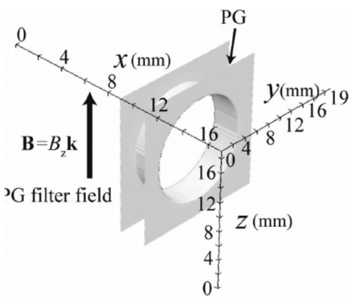

Fig. 1 Simulation domain in the present model.

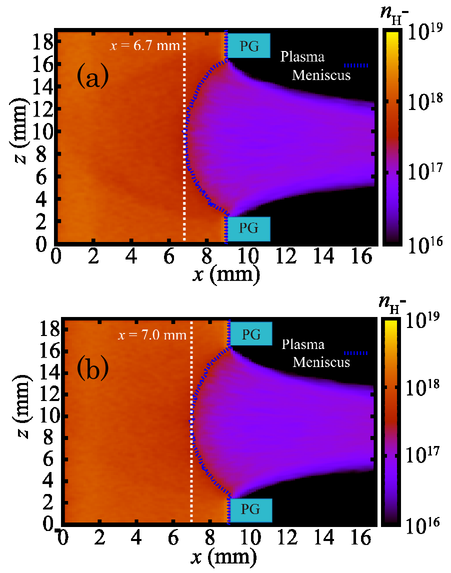

Fig. 2 2D H- profile in the *x-z* mid-plane.
(a) w/o CXC and CC and (b) w/ CXC and CC.

The input plasma parameters and boundary conditions are described in Ref. [2].

3. Results

Figure 2 shows the preliminary results of the 2D H^- density profiles and the shape of the plasma meniscus. In Fig. 2, the following two cases are shown; (a) w/o CXC and CC and (b) w/ CXC and CC. From the comparison between Fig. 2(a) and (b), it has been shown that the penetration of the plasma meniscus into the source region becomes small due to CXC and CC.

Moreover, the ratio of the beam halo component to the extracted H^- ion beam current (P_{halo}) in each case has been estimated in the quasi-steady state. The P_{halo} is estimated to be 30.5 % in the case (a) and 23.4 % in the case (b). From these results, it has been shown that the P_{halo} is reduced due to the CXC and CC. The detail physical process of these effects will be discussed in the poster session.

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