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Hydrogen Ionic Plasma and Particle Dynamics in Negative Ion Source for NBI

KATSUYOSHI TSUMORI, National Institute for Fusion Science

Three negative-ion-based neutral beam injectors (NBIs) have been developed for plasma heating in the Large Helical Device. The NBIs achieve successfully the nominal injection power and beam energy [1-3], and understanding of the production and transport mechanisms of H^- ion is required to obtain more stable high power beam. In the ion source development, we have found hydrogen ionic plasmas with extremely low electron density are produced in the beam extraction region [4]. The plasma is measured with a combination of an electrostatic probe, millimeter-wave interferometer and cavity ring down (CRD) [4-6]. It has been observed for the first time that the charge neutrality of the ionic plasma is broken with H^- extraction and electrons compensate the extracted H^- charge [4]. The influence of the extraction field widely affects to the ionic plasma in the extraction region [4, 6]. Two-dimensional particle-in-cell simulation (2D-PIC) has been applied to investigate the particle transport and reproduces the production of the ionic plasma and electron compensation due to H^- extraction [4, 7]. In particle model, produced H^- ions leave from the Cs covered PG surface in opposite direction to beam extraction. The direction can be changed with the electric field and collective effect due to the presence of plasma. A new technique using CCD camera with Hα filter applied to measure the two-dimensional distribution of H^- density [8]. In the ionic plasma, Hα light is emitted via electron-impact excitation and mutual neutralization processes with H^- ion and proton. Comparing the results obtained with optical emission spectroscopy, electrostatic probe and CRD, it is shown the Hα emission is dominated with the mutual neutralization. By subtracting the CCD images with and without beam extraction, it becomes clear that H^- ions are extracted not directly from the PG surface but from the bulk of the ionic plasma [8]. The result suggests the initial energy of H^- ion is dumped rapidly in the ionic plasma.

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