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Response of charged particle flows to the extraction field in a negative hydrogen ion source for NBI

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Negative ion sources have been widely used for high power and high energy neutral beam injection for plasma heating and current drive in fusion research due to the high neutralization efficiency of negative ion beam at high energy. Negative ion (H^-) rich plasma has been observed in the beam extraction region of the research & development negative ion source at NIFS (NIFS-RNIS). The negative ion rich plasma in which the H^- ion density is much higher than electron density is influenced by the extraction field and contaminated by the electron diffusing from driver region during beam extraction. As a consequence, the ratio of H^- ion density to electron density deceases after the extraction field is applied. In order to understand this phenomenon, investigation on charged particle dynamics is required. Therefore, experiments have been conducted to measure the response of charged particle flows to the extraction field in the beam extraction region.

A four-pin probe with photodetachment has been applied for the charged particle flow measurements. The four-pin probe can work in electrostatic and photodetachment modes. The negatively and positively charged particle flows were measured by switching the probe to electrostatic mode. The H^- ion flow was obtained by switching the probe to photodetachment mode.

Figure 1 shows the negatively charged particle flow direction before and during beam extraction, including electrons and H^- ions. The flow direction at z = 19 and 26 mm mainly indicates the electron flow since the probe is more sensitive to the electrons. At z = 12 mm the flow direction is influenced by the H^- ions produced on the plasma grid (PG) surface. During beam extraction, the flow direction at z = 12 shows an obvious change.

The H^- ion flow before and during beam extraction is shown in Fig. 2. The extraction field does not change the H^- ion flow obviously. This phenomenon can be understood by considering the H^- ion density. In pure hydrogen plasma without Cs, the H^- ion density is ~1×10^{17} /m^3, which increases to ~3×10^{17} /m^3 after seeding Cs. It indicates in the Cs-seeded plasma, the H^- ions are mainly produced on the PG surface. During beam extraction, the H^- ion density decreases to ~2.4×10^{17} /m^3 which is still higher than the volume produced H^- ion density. Only a small part of surface produced H^- ions are extracted. Therefore, during beam extraction, the H^- ions are still produced from the PG surface and the mean flow of H^- ions does not have an obvious change.

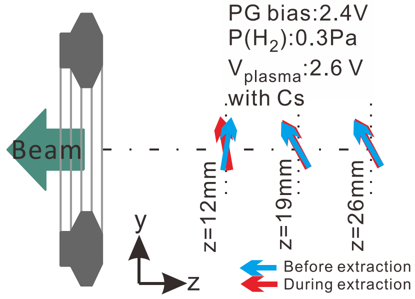

Figure 1. Negatively charged particle (including electrons and H^- ions) flow before and during beam extraction.

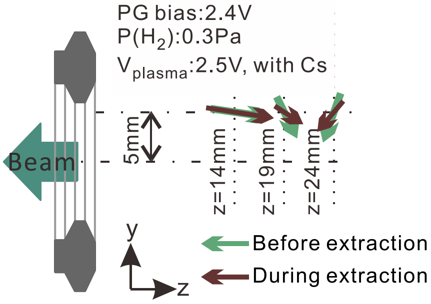

Figure 2. H^- ion flow before and during beam extraction.