24pD39P

シートプラズマを用いたセシウムフリー負イオン源開発に向けてのH⁻引き出し実験

Experiment of H^- extraction for development of cesium-free negative ion source by using sheet plasma

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Negative hydrogen ion neutral beam injection (N-NBI) plays an essential role in heating and current driving in ITER. A negative hydrogen ion beam with an energy of 1 MeV and a current of 40 A (a current density of 20 mA/m^2) is required for 3600 s to produce 16.5 MW of power. NBI predominantly uses negative hydrogen ion sources based on surface production. These negative hydrogen ion sources require cesium seeding to achieve a high ion density. However, cesium seeded surface-production of negative hydrogen ions is not desirable from the point of view of stability because effects including breakdown between electrodes can occur. We demonstrated the production of negative hydrogen ions in cesium-free discharge by using the magnetized sheet plasma of linear plasma simulator TPD-Sheet IV [1]. We were confirm that there is negative hydrogen ions by mass spectrometry and performed an experiment of negative hydrogen ion extraction. Under a secondary hydrogen gas entering the hydrogen plasma, the peak position of the hydrogen plasma n_{H^-} is localized in the periphery of the sheet plasma. It is found that hydrogen negative ions are formed by the dissociative attachment of low energy electrons (T_e = 1-2 eV) to highly vibrationally excited molecules, which are attributed to the electron-impact excitation of molecules by high energy electrons (T_e > 10 eV) in the plasma column, and are transported to the periphery of the sheet plasma. The maximum negative hydrogen ion beam is successfully extracted using grids located in the periphery of the sheet plasma. The negative hydrogen ion current density is about 20 mA/cm^2 at extraction voltage is 2 kV at a neutral gas pressure of 0.3 Pa and discharge current of 50 A. We considered that the negative hydrogen ion current against the extraction current is 70% from the ratio of the total extraction current and the electron extraction current. The various extraction current densities are on the same order as the calculated result which from Child-Langmuir law. These results are in good agreement qualitatively. These results imply that negative hydrogen ions in sheet plasma are successfully extracted.

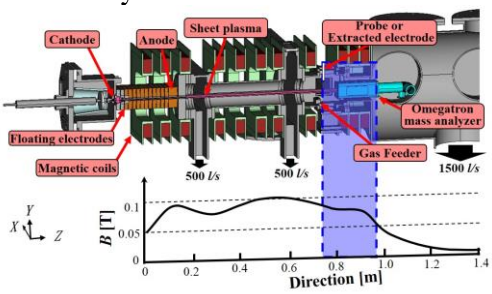

Fig. 1 Schematic diagram of the experimental setup TPD-SheetIV.

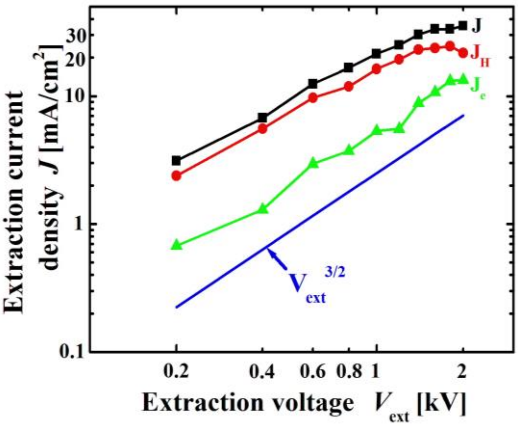

Fig. 2 Characteristics of the various extraction current density (H-, e, H-+e) as a function of the extraction voltage at the periphery region (14mm) of the sheet plasma.

[1] T. Iijima, et al., Ion acceleration by ion-cyclotron resonance in non-uniform magnetic field using the TPD-SheetIV linear divertor simulator, Fusion Science and Technology 63 (2013) 417.