§21. A Design Study of Photodetachement with Faraday Cup technique on NIFS Research and Development Negative Ion Source

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Negative hydrogen ions extracted as beam are produced on a plasma grid surface which is a boundary electrode between the ion source plasma and beam in cesium seeded negative hydrogen ion source. One of the important things to improve the performance of the negative-hydrogen ion source is understanding of the dynamics from the negative-hydrogen ion production to extraction as beam. The neutral beam group in NIFS has performed to study the dynamics by measuring negative-hydrogen ion density and temperature, electron density and temperature, cesium neutral density, plasma space potential, and optical emission and absorption from plasma in large-scale negative-hydrogen-ion source whose name is NIFS-RNIS. However, it has not been known whether the surface-produced negative-hydrogen ions are directly extracted or are extracted after distributing in the space in the vicinity of the plasma grid, and whether there are both routes or not. The final objective of this study is to elucidate the route and dynamics of the negative hydrogen ions from the production to the extraction.

A PhotoDetachment with Faraday Cup technique (PD-FC) was performed to find the negative hydrogen ion extracted as beam in the vicinity of the plasma grid in small scaled negative hydrogen ion source with single beamlet in Ref 1. In the PD-FC, the negative hydrogen ion is neutralized to hydrogen atom by electron photodetachment reaction by a Nd:YAG laser light of 1064 nm in wavelength injected to the vicinity of the plasma grid during the beam extraction phase. Since the neutralized hydrogen atom cannot be extracted and accelerated as beam, the Faraday cup signal by negative-hydrogen-ion beam changes. In Ref. 1, the signal change was observed not only in the pure hydrogen discharge where the negative hydrogen ions are produced in the space but also in the cesium seeded hydrogen discharge. This indicates the negative hydrogen ions are extracted from the space in the both discharges. The negative-hydrogen ions density does not increase very much in this small ion source. In the NIFS-RNIS which has a comparable potential of the enhancement of negative-hydrogen-ion beam current by cesium seeding with the negative-hydrogen-ion source for LHD-NBI, the amount of the surface-produced negative-hydrogen ions should be much higher than that of the negative-hydrogen ions produced in the space. The surface-produced negative-hydrogen ion dynamics can be more clearly appeared in the PD-FC on the NIFS-RNIS.

A design study of the PD-FC on NIFS-RNIS started. One of the diagnostic ports on the bias insulator between the arc chamber and the plasma gird flange was selected to inject the Nd:YAG laser light which can pass through in the vicinity of the plasma grid. The laser path can move in the vicinity of the plasma grid by an optical system of the movable cavity ringdown technique on the NIFS-RNIS [2], and the laser shape can change by lenses and/or various shape apertures. A beam of the NIFS-RNIS consists of multi-beamlets which diverge by a space charge effect. One of the problems is how far the Faraday cup is put from the NIFS-RNIS. The position of the Faraday cup which can detect the beam signal before the each beamlet not superimposing was found from beam simulations and beamlet monitor experiment in the NIFS-RNIS [3]. The diagnostic port to set the Faraday cup at the position was determined on the drift tube between the NIFS-RNIS and the ion source column of the beam line. A diagnostic flange on the diagnostic port was newly designed and fabricated. There are several small ports on the diagnostic flange. One of the small port will be utilized for electrical connector of Faraday cup signal. Due to high beam current density (approximate 100 A/m^2) and energy (approximate 80 keV), the Faraday cup is exposed by huge thermal load. The Faraday cup structure with cooling system and temperature measurement, and the utilizing small port for the cooling channels and the temperature measurement were considered. From Ref. 1, the electrical circuit with time constant less than micro second order, and the analog-digital converter with time resolution less than 1 μs have been prepared. In the next fiscal year, the optical system for the laser injection and the Faraday cup will be designed in detail and be fabricated. By assembling these components, initial data of the PD-FC on the NIFS-RNIS will be obtained.

1) Y. Matsumoto *et al*., Review of Scientific Instruments **75** (2004) 1757.
2) H. Nakano *et al*., AIP conference proceedings **1515** (2013) 237.
3) P. Veltri *et al*., Review of Scientific Instruments **87** (2016) 02B908.