§7. The Role of an Electric Field for H^- Extraction in a Hydrogen Negative Ion Source

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Neutral beam injection(NBI) systems have been used to heat the core plasmas in LHD, and future thermo-nuclear fusion devices. The transport mechanisms of hydrogen negative ions(H^-) in an ion source plasma should be understood enough to be able to develop higher efficient ion sources in view point of H^- extraction. We study H^- transport with experimental and calculational approaches, especially, to make clear the relation between H^- extraction probability and plasma potential structure.

In the experiment, laser photodetachment with Langmuir probe(PD-LP) and photodetachment with Faraday cup(PD-FC) are used(Fig.1). They are utilized to measure H^- density and the amount of extracted H^- ions from ion source, respectively. These data are combined to estimate H^- extraction probability from an ion source. The spatial distribution of H^- extraction probability with this method is showed in Fig.2. It has about 4.5% as a maximum value at 0.3cm, and decreases with distance from the extraction hole.

Furthermore, we calculate H^- orbit with Monte Carlo procedure to analyze these experimental results. As a first step, a simple plasma potential geometry, which it has potential gradient only in Z direction and an electric filed of X and Y direction is uniform, is assumed. The calculational result is showed in Fig.2. It is 1-2 order smaller than the experiment. It indicates that the other potential geometry should be applied at an extraction region. Therefore, we assume a potential structure that has a hill on the center of ion source axis; A beam extraction electric field affects the ion source plasma through the extraction hole. The geometry is showed in Fig.3. As the calculation results with the potential, H^- extraction probability drastically increase and improve in comparison to the experimental result.

An electric field in radial direction is arisen by the existence of the potential hill. It pulls H^- ions to the center of the ion source. It helps H^- transport toward the extraction hole, and makes increase the extraction probability. From this result, it makes clear that a potential structure in front of an extraction hole is a key factor for H^- extraction from an ion source.

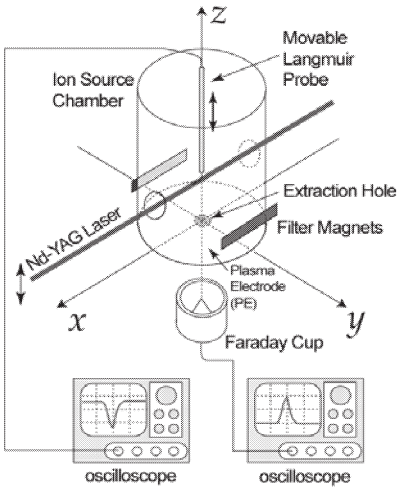

Fig. 1. Experimental setup

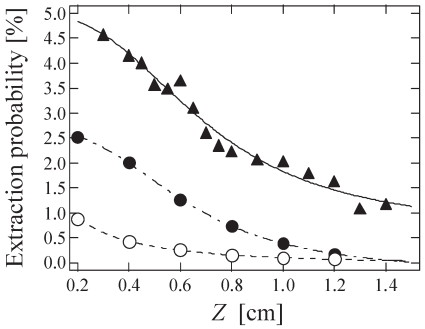

Fig. 2. Z dependence of H- extraction probability from the ion source. ▲ is experiment, ● and ○ are calculation result with the affection of the extraction electric field, and without it, respectively.

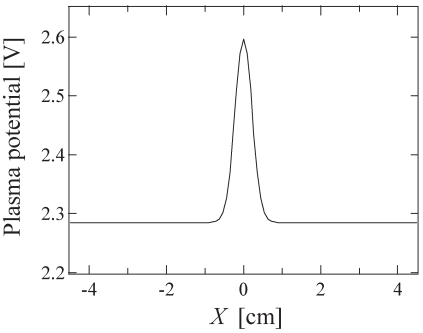

Fig. 3. Assumed potential structure for the calculation affected by an extraction electric field.

Reference

1) Y.Matsumoto, M.Nishiura, K.Matsuoka, M.Sasao, M.Wada, and H.Yamaoka, Thin Solid Films Vol.506-507, 522-526 (2006)