§16. An Injection Technique of Tracer Impurities Based on Sputtering from a Material Target

Mizuuchi, T. (IAE, Kyoto Univ.)

Although the purity of the plasma is one of the important parameters to keep high temperature plasmas, a small amount of impurity species, which are artificially injected into the plasma, give us a lot of valuable information on the magnetically trapped plasma behavior. The core plasma transport is discussed in many confinement devices based on spectroscopic data of "tracer" impurities injected by using a laser blow-off technique and/or a pellet injection technique. The observation of a pellet ablation cloud has a potential for q-profile measurements. Gas injection methods are also used especially in the plasma edge region. So-called atomic beam diagnostics are a powerful tool to investigate edge plasma density profile and fluctuations. The effect of divertor screening is also investigated by using impurity gas puffing in several machines. Moreover, as discussed in Alcator C-Mod, plasma-neutral momentum coupling can be studied based on asymmetric D_α "plumes" during capillary gas injection. A combination of a surface analysis probe with a tracer impurity injection can provide useful data on impurity transport and/or recycling in the edge region.

As another tracer impurity injection method, especially for investigation of impurity behavior in the core edge region, K. Kondo (GES, Kyoto Univ.) and I propose to use sputtering from a small target material irradiated to the plasma. This method can clearly localize the source position basically anywhere we want by using a proper transport mechanism. Langmuir probes installed near the target can identify the incident plasma parameters such as ion (electron) density, electron temperature, incident ion velocity, etc. Here, target biasing might be effective to control the incident ion energy. The multi-directional spectroscopic measurement viewing the target periphery region can show information on sputtered particles such as the particle number, the initial velocity, ionization processes, etc. Therefore, this method has a potential to provide a clearly identified point source of a tracer impurity. If the target is set on a fast reciprocating mechanism, the irradiation (i.e. impurity injection) timing and duration can be controlled. This impurity injection technique is rather easy to introduce even in a small experiment.

As an initial step on the way to development of a realistic diagnostic technique based on the above idea, we have prepared a movable target system for Heliotron J.

Figure 1 shows the target system before installation. This system is designed as a combination system with a small test limiter. The limiter head is made of graphite and has a cannonball shape (90 $mm^{\phi}\times 62\ mm^{H}$). This limiter head is installed a long span (450 mm) linear transporter. A tiny (~ $4\times 6\ mm^2$) target, which is retractable inside the limiter head in order to avoid surface contamination during the wall conditioning, is set on this transporter system with another short span linear transporter and can be pushed out from the limiter top surface up to ~ 40 mm. Since, unfortunately, both of these two transporters can make no fast reciprocating action, the position of the target (and also the limiter position) is fixed at one radial position during a single discharge. Since the whole system is electrically floating from the vacuum chamber, it would be possible to charge a bias voltage to cause the sputtering even in a low temperature plasma region.

The target material should be selected from several viewpoints: sputtering characteristics, atomic process database, easiness of detection, etc. As a tracer impurity for this first experiment, we selected Si and used a tiny block of SiC as a target. Close to the both sides of the target surface, four Langmuir probes (two probes par one side) are installed to measure plasmas coming from parallel and anti-parallel directions. This probe system will also provide some information on plasma flow along the field line.

This target/limiter system is inserted to the vacuum chamber from the bottom of the Heliotron J. From the opposite port, the target is monitored with a CCD camera and line spectra radiated from injected neutrals and/or low-ionization-state ions in the vicinity of the target are simultaneously monitored with two-dimensional imaging spectroscopy. The behavior of higher ionized particles is monitored by measuring spectra radiated from such ions with a VUV system and/or a SX system at different toroidal positions.

The plasma experiment in Heliotron J will re-start from summer in 2001.

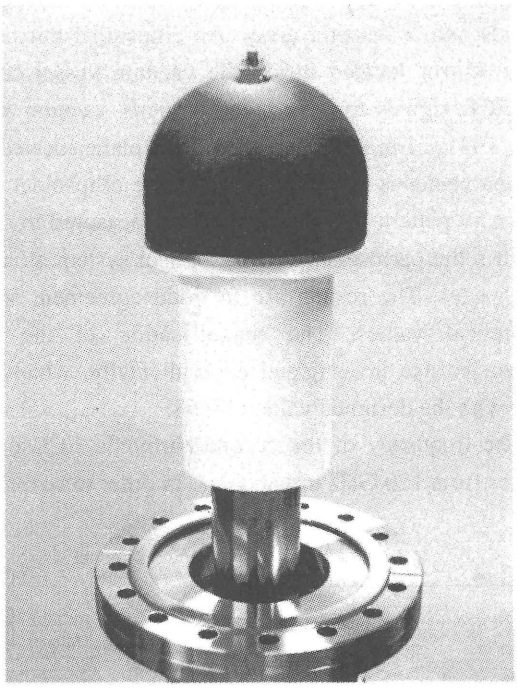

Fig. 1 A photograph of the target/limiter head for the Heliotron J experiment. The target is pushed up about 10 mm from the top of the limiter head.