§35. Studies of Fast-Ion Orbit Loss in LHD

Morimoto, S., Kitano, T. (Kanazawa Inst. of Technology), Shoji, M., Yanagi, N., Komori, A., Yamazaki, K., Motojima, O.

Confinement of alpha particles and removal of helium ashes are very important to realize D-T fusion reactors. To simulate experimentally behavior of alpha particles in helical fusion reactors, we launch potassium ions (K^+, energy~keV) from a miniature ion gun located at a defined positions in the vacuum vessel of the LHD under the toroidal magnetic field of B=(1~1.5) T. Its confinement properties are estimated by the modified stellarator diode method. Thus we can simulate the alpha particle motions in helical fusion reactors.

In the last year, we have developed the thermionic-type miniature ion guns, which can emit potassium ions in one direction with the beam energies of E~1keV and the currents of I_B=(10~50) μA. This year, an ion gun which emits K^+ ions in all directions has been developed. This gun simulates well the situation of alpha particle production since the alpha particles would be born with an isotropic initial velocity distribution. This gun provides another advantage that higher beam currents are obtained compared to the directional ion gun. Figure 1 shows its structure schematically. The ion emitting material is the so-called molecular sieve (type 3A, $K_{12}[(Al_2O_3)_{12}(SiO_2)_{12}] \cdot 27H_2O$) which is coated onto the surface of a cylindrical heater (Heat Wave Inc, Model-1123, 6.4mm in diameter). The heater is sandwiched by the boron-nitride disks and indirectly heated (heating power < 27W) with a molybdenum filament. The molecular sieve was coated and sintered at ~1200°C 2~3 times.

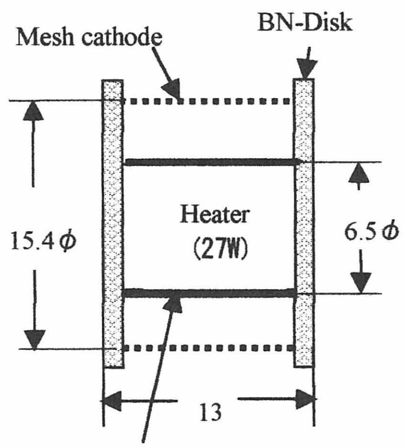

Fig.1. A schematic drawing of the cylindrical K^+ miniature ion gun.

A mesh cathode (stainless steel, transparency 80%) is placed in front of the emitter (distance~4mm) and an extraction voltage V_B is applied between the cathode and the emitter. With this gun, the emission current of ~100μA was obtained at the bias voltage of 1000V and the emitter temperature of ~1000°C.

Studies of the stellarator diode method has been continued on Heliotron DR (B ~ 0.05 T) using a miniature electron gun which has the mesh-anode with a high transparency (~80%). In this method, we measure the electron current flowing not to the vacuum-wall but to the anode to estimate the electron confinement. Figure 2 shows the anode current normalized by the emission current from the filament (I_A/I_T) versus the radial position of the electron gun for different bias voltages of V_B=(10~800) V. In the central region, it is ~1 which indicates that electrons are well confined. However, in the peripheral region, the confinement becomes worse and seems to be better at lower bias voltages of V_B≤100 V. We have measured the space potential inside the vacuum chamber by an electrostatic probe and found that the effect of the space potential should be considered at V_B≤100 V. We have also discussed the experimental result that the electron confinement seems to be better at the rational magnetic surfaces.

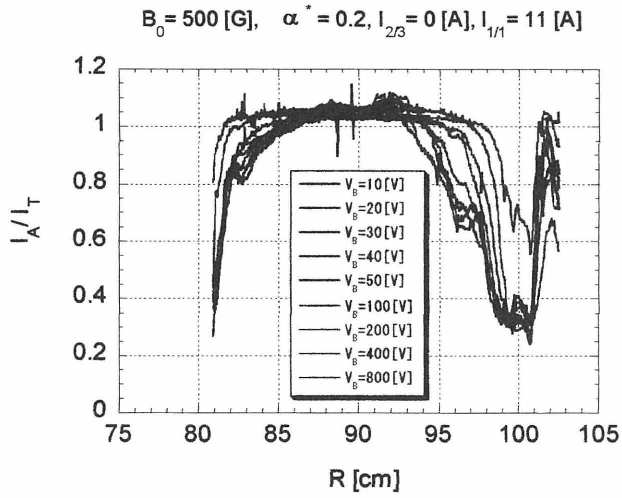

Fig.2. Normalized anode current (I_A/I_T) versus the radial position of the electron gun for different bias voltages.

A simulation experiment on the fast ion injection from outside of the last closed magnetic surface into the core region of the helical device has also been carried out on Heliotron DR using an electron gun. We have observed that when the electrons are launched from appropriate azimuthal positions, they are detected near the magnetic axis with an electrostatic probe.