§31. Study of Selective Exhaust of Particles on LHD Closed Divertor

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Selective exhaust of particles in the divertor region is one of the key problems in the steady-state operation of nuclear fusion devices. Ion cyclotron resonance heating (ICRH) of plasma can be applied to mass separation with a small fractional mass difference. This technique of the separation can be applied to many applications, such as, separation of deuterium and tritium for the fuels of nuclear fusion, selective removal of helium from nuclear fusion reactor.

The first successful experiment to demonstrate this idea was carried out by Takayama and his coworkers at the Institute of Plasma Physics, Nagoya[1]. We have proposed to perform mass or isotope separation by ICRH in a sheet plasma on the linear plasma divertor simulator TPD-Sheet IV[2-4]. The sheet plasma is a special type of strongly magnetized highly ionized slab plasma. The sheet plasma has thickness which is as thin as twice the mean ion Larmor radius, in a direction perpendicular to a magnetic field. Guiding centers of all gyrating ions in the plasma are lain in the vicinity of the mid-plane of the plasma by the thickness. Because of these characteristics energetic ions in a sheet plasma traverse the dense plasma region only momentarily in each cyclotron gyration. As a result, the adverse effect of collisions to mass separations by ICRH can be negligible small.

The purpose of the present work is to demonstrate high heat flux plasmas for fundamental research on divertor plasmas in magnetically confined fusion devices. In this paper, we report the experimental simulation of ICRH of the helium sheet plasma (~10^{18} m^{-3}) by the RF electrodes of two parallel plates, sandwiching the sheet plasma. Measurements of the ion temperature in the plasma were carried out by a fast scanning Faraday cup.

The TPD-SheetIV device consists of the sheet plasma source, magnetic coils, RF heating part, a measurement part, end chamber, a vacuum exhaust, and a Faraday cup. The plasma in TPD-Sheet IV is divided into two regions; the sheet plasma source region and the experimental region. The hydrogen sheet plasma is produced by a modified test plasma generated by direct current (TPD)-type DC discharge. The anode slit is 2 mm thick and 40 mm wide. Ten rectangular magnetic coils form a non-uniform magnetic field of 0.1 T in the experimental region. The magnetic field at the center of the RF electrodes has a large gradient of *ca.* 0.35 T m^{-1} when B_{max} = 0.1 T. Efficient heating in the sheet plasma is thus expected due to the low collision frequency of ions. Therefore, the sheet plasma can be easily heated using a simple electrode structure, such as two parallel plate electrodes. The plasma density is varied between 10^{17} m^{-3} and 10^{19} m^{-3}, while the electron temperature is maintained at 7-10 eV.

The RF application circuit consists of an RF power supply, a matching circuit, and RF electrodes. The RF power supply consists of a function generator, a, RF amplifier, and a power meter. The maximum output of the RF power supply is approximately 500 W. The matching circuit consists of an LC circuit and a BAL-UN circuit, and transmits electric power without loss. The RF electrode is two parallel plate electrodes that are 200 mm long and 60 mm wide and face each other 38 mm apart. The plasma is sandwiched between the two parallel plate electrodes. The RF frequency can be swept from 0.8 to 1.5 MHz with a constant RF voltage.

The electron density and electron temperature are measured with a fast scanning Langmuir probe. The ion temperatures, $T_{i\perp}$ and $T_{i//}$, are measured with a fast scanning Faraday cup and a Faraday cup at the end target, respectively.

Figure 1 shows the dependence of the ion temperature $T_{i\perp}$, on f_{RF} at a discharge current of 50 A in helium plasma. The position of the Faraday cup in the Y-direction is 5.0 mm. The magnetic field B is 0.1 T and the applied RF power is 300 W. The ion temperature $T_{i\perp}$ increases from 3.7 to a maximum of 5.3 eV for an fRF of 523 kHz, which is slightly higher (~1.3 fci) than the ion cyclotron frequency of helium, fci. Ion energy in the direction perpendicular to the magnetic field line is increased by ICR.

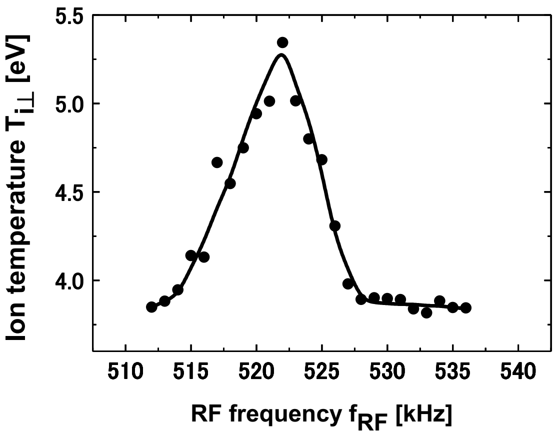

Fig.1. Ion temperature $T_{i\perp}$, plotted for various RF frequencies at a power supply of 300 W.

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