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Selective removal and collection of Ion by ICR heating in magnetized sheet plasma
シートプラズマを用いた ICR 加熱法による He イオンの選択的分離・回収

Daiki Hamada, Satosi Hagiwara, Akira Tonegawa, Kazutaka Kawamura, Kounosuke Sato
濵田 大樹, 萩原 聡, 利根川 昭, 河村 和孝, 佐藤 浩之助

Department of Physics, School of Science, Tokai University,
1117 Kitakaname, Hiratsuka, Kanagawa, 259-1292, Japan
東海大学 理学部 物理学科 〒259-1292 神奈川県平塚市北金目 411

The pumping of helium ash has become important for the control in the edge plasma of the divertor because of the helium ash has limit of concentration. We have demonstrated the ion cyclotron resonance (ICR) method of the helium or helium/hydrogen sheet plasma by the RF electrodes of two parallel plates, sandwiching the plasma. Measurements of the ion temperature in the plasma were carried out a fast scanning Faraday cup. In addition, the ion densities in the plasma were measured by an omegatron mass analyzer and the neutral densities of resonant ions was measured by a quadruple mass analyzer. The ion temperature shows maximum amount when the rf frequency is nearly equal to ion cyclotron frequency. When the rf power is applied to 0 W to 400 W, the ion temperature in the periphery of the plasma is increase than that of the central region.

1. Introduction

It has been shown that the end loss from the line cusp can be plugged effectively when an RF field near the ion cyclotron frequency is applied at the line cusp [1]. Also, the methods to improve the helium removal performance of a pump limiter by using a RF ponderomotive force (RF-filter) were presented [2]. The selective removal of helium ash using by ion cyclotron resonance (ICR) method has been studied in a linear divertor simulator, TPD-SheetIV [3]. We have demonstrated the ICR method of the helium or helium/hydrogen sheet plasma by the RF electrodes of two parallel plates, sandwiching the plasma. Measurements of the ion temperature in the plasma were carried out a fast scanning Faraday cup. In addition, the ion densities in the plasma were measured by an omegatron mass analyzer and the neutral densities of resonant ions was measured by a quadrupole mass analyzer.

2. Experimental apparatus

A schematic diagram of an experimental apparatus TPD-SheetIV is shown in Fig.1[3]. The TPD-SheetIV device consists of the sheet plasma source, magnetic coils, RF heating part, a measurement part, end chamber, a vacuum exhaust, the Faraday cup and a omegatron mass analyzer apparatus. Figure 1 shows the schematic diagram of the measuring system and the RF applying circuit. The RF applying circuit consists of the RF power supply, a matching circuit and RF electrodes. The RF power supply consists of a function generator, a

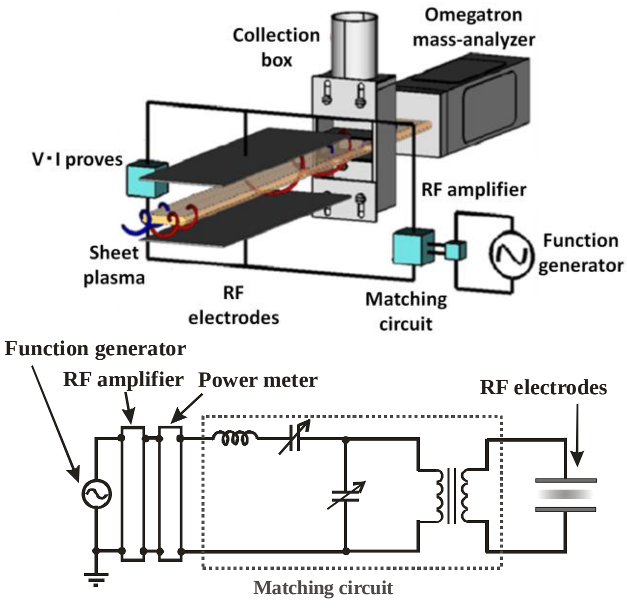

Fig.1 Schematic diagram of the measuring system and a RF power supply. $T_{i\perp}$ was measured by a fast scanning Faraday cup system.

RF amplifier and a power meter. The maximum output of the RF power supply is about 500 W. The matching circuit consists of a LC circuit and BAL-UN circuit and transmits the electric power without loss. The RF electrode is two parallel plate electrodes which are 200mm in length and 60 mm in width which are faced 38 mm apart from each other. The plasma is sandwiched between the two parallel plate electrodes.

3. Experimental Results

Figure 2 shows mass spectrum of the omegatron mass analyzer at a discharge current Id of 45 A in the helium and hydrogen mixture plasma. The applied RF frequency f_{RF} is 500 kHz corresponding to the resonance frequency of helium plasma. The RF power changes from 0 to 450 W. Mass spectroscopy is performed by applying an RF field to the parallel plate of the omegatron and measuring the resulting current on the collector plate. Analysis of the ion trajectories in a uniform rf field applied perpendicular to a constant uniform magnetic field shows that the ions execute spiral orbits with a maximum excursion radius. From a typical plasma omegatron spectrum, it can be seen that the peaks correspond to H^+, H2 $^+$ and He^+ without RF power. The peak identification is carried out by comparing the observed peak frequencies, which is the cyclotron frequency decided by the magnetic field in the omegatron. The ion current of He^+ gradually decreases with increasing RF power.

Figure 7 shows the dependence of the RF power P_{RF} on the content of the He^+ ion α at the RF frequency is 500 kHz corresponding to the resonance frequency as shown in fig.4. The ion density is given by

$$\boldsymbol{N_i \propto I_i \sqrt{M_i}}\ ,$$

where I_i and m_i are the ion currents of omegatron and the ion masses, respectively. The content of the He^+ ion α is defined as

$$\alpha = \frac{N_{He}}{N_{He} + N_{H2} + N_H}\ ,$$

where N_{He}, N_{H2} and N_H are the density of He^+, H_2^+ and H^+, respectively. The ion densities N_i of H^+ and H_2^+ gradually decrease with increasing the P_{RF}, although He^+ rapidly decreases with increasing P_{RF}. As the result, α increases from 34.5% to 37.5%. It is found that the selective heating of the helium ions

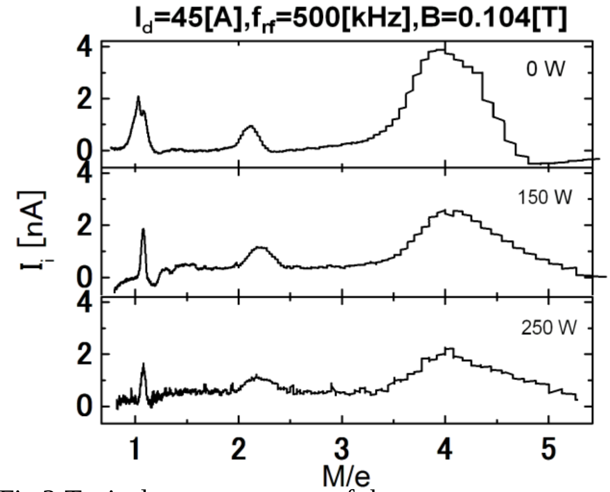

Fig.2 Typical mass spectrum of the omegatron mass analyzer at a discharge current I_d of 45 A in the helium and hydrogen mixture plasma.

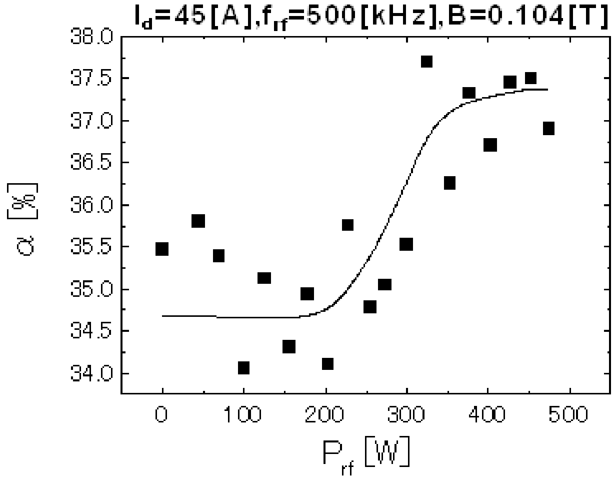

Fig.3 Dependence of the RF power P_{RF} on the content of the He^+ ion α at the RF frequency is 500 kHz corresponding to the resonance frequency.

in the sheet plasma is successful by using ICRF.

4. Conclusions

We have demonstrated the ICRH of the helium sheet plasma by two parallel plate electrodes, sandwiching the plasma. The ion densities Ni of He^+ rapidly decreases with increasing the PRF, although H^+ and H2$^+$ gradually decrease. As the result, α increases from 34.5% to 37.5%. It is found that the selective heating of the helium ions in the sheet plasma is successful by using ICRF.

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