Development of electric propulsion using ICR heating on TPD-Sheet IV

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The electric propulsion using an ion cyclotron resonance (ICR) heating on our experimental apparatus TPD-Sheet IV has been developed to control the thrust and specific impulse by manipulating RF powers for plasma production and ion heating. Ion acceleration of high density sheet plasma (~10^{18} m^{-3}) in divergent magnetic field by ICR is investigated. The RF electrodes are made of two parallel plates. The ion energy in the perpendicular direction was measured by a diamagnetic loop coil. The experimental condition is helium gas and discharge current 30~50 A. Ion energy in the perpendicular direction of the magnetic line increased by the ion-cyclotron resonance. Also, ions were accelerated along the axis of the magnetic line by divergent magnetic field.

1. Introduction

An electric propulsion system is one of the key elements in future space exploration projects and has been developed for various space missions. Development of a high power-density plasma thruster with a higher specific impulse and a larger thrust is prerequisite for a manned interplanetary space thruster [1]. Development of Variable Specific Impulse Magneto-plasma Rocket (VASIMR) engine proposed by NASA's Dr. F. R. Chang Diaz et al has proceeded. In this system, the thrust and the specific thrust are controlled freely by manipulating in powers for plasma production and ion heating and various engine operations according to the mission situation can be realized. [2]. The ion cyclotron resonance heating (ICRH) causes perpendicular direction ion heating, followed by the energy conversion from the perpendicular to parallel direction by divergent magnetic field. In the steady state plasma, experimental results of the ion heating have been reported in the low-density plasma (~10^{17} m^{-3}) by ICRH [3].

In this study, experimental of ion acceleration of high-density sheet plasma (~10^{18} m^{-3}) in the steady state by ICRH has been conducted on a linear plasma device TPD-Sheet IV. Since the thickness of the plasma sheet is small, which is about twice of an ion Larmor radius, efficient ion heating with relatively lower powers by using ICRH can be expected.

2. Experimental Setup

Shown in Fig.1, The TPD-Sheet IV device consists of the sheet plasma source, magnetic coils, radio-frequency (RF) heating part, a measurement part, end chamber, a vacuum exhaust. With a magnetic field power source (300 A, ~60 V) and nine coils, maximum magnetic field of 0.12 T can be generated in the heating region. Various magnetic field structures can be formed by using a small power source (300 A, ~10 V) for the two coils at z-axis direction end of the device.

The RF applying circuit consists of the RF power supply, a matching circuit and RF electrodes. The maximum output of the RF power supply is about 500 W. The RF electrodes is a parallel flat plate with a width of 60 mm and a length of 200 mm and experiments were conducted in the excitation frequency range of 200 to 600 kHz. The plasma is sandwiched between the two parallel plate electrodes.

The electron density and the electron temperature are measured by a fast scanning Langmuir probe. The ion temperature $T_{i\perp}$ and $T_{i//}$ are measured by the diamagnetic loop coil and a Faraday cup, respectively. The thrust measured was conducted by a target pendulum [3].

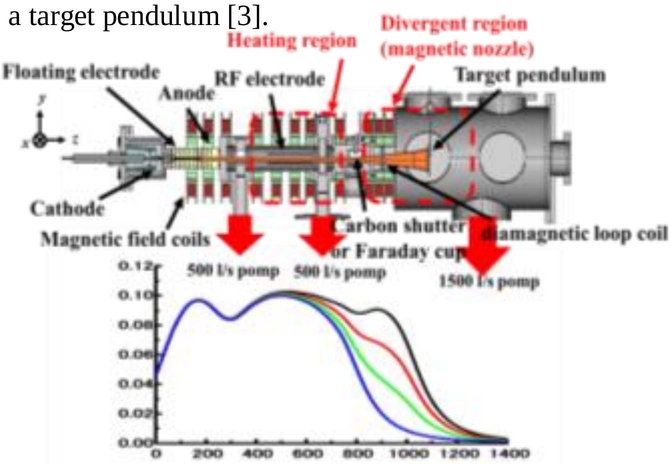

Fig.1. Schematic diagram of TPD-Sheet IV

3. References

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