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Development of Experimental Devices for the Research of Self Trapping and Nonlinear Behavior of Plasma Waves
電子ビームの自己捕捉とプラズマ波動の非線形性の研究装置の立ち上げ

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We are preparing experiments by using the CALM2 machine. For the first step, we measured the plasma by Langmuir probe. The specification of CALM2 is described, and parameters of the first plasma are reported here.

1. Introduction

The electron plasma waves are excited in the beam-plasma system and make wave packets. The wave packet undergoes glowing, saturation, and damping in the time scale of electron response. It is known that the growing phase is governed by a linear equation [1]. But understanding of the saturation and damping phases need more researches and discussions. Measurement of the non-linear phenomena is our major concern. In general, part of the electrons of the beam is trapped in wave potential, and non-linear phenomena occur. To observe the process, experimental research was carried out, and the trapping of beam electron and saturation were observed dynamically in CALM2 (Coaxial Linear Machine-II) in Shizuoka university [2,3].

The CALM2 is replaced to Kanazawa university, recently. We are preparing experiments by using the machine. For the first step, we measured the plasma of CALM2 by using Langmuir probe. We introduce the CALM2 and the plasma parameters are reported here.

2. Experimental Device

The configuration of CALM2 is shown in Fig. 1 and Fig. 2. It is the multi-pole magnetic device, and it can produce quiet plasma [4]. The vacuum chamber is 0.26m in diameter、1.2m in the axial length. Magnetic coils are placed outside of the chamber, and can produce axial magnetic field. The background pressure is 10^{-7} ~ 10^{-8} [Torr]. Tungsten filaments are set inside the chamber, and those are heated and biased by the DC voltage, and emit thermionic electrons. The first electrons ionize the neutral gas, and produce plasma.

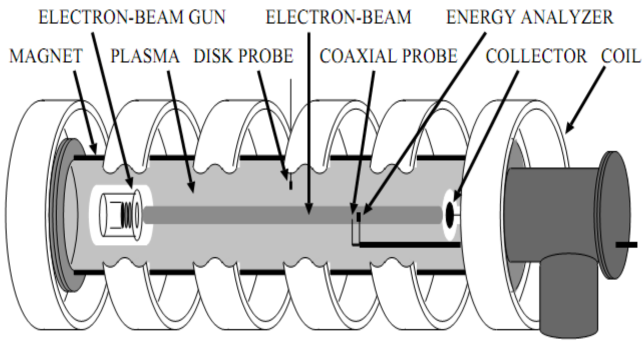

Fig. 1 Coaxial Linear Machine-II, CALM2

On the outside wall of the chamber, permanent magnet bars, Sm-Co, are attached, 12 for side wall, and 10 for each end walls. The magnetic field is about 0.1 [T] at the surface of the magnet bar. The magnetic polarity is reversed one by one to form the full-line-cusp magnetic field, see figure 2. The magnetic fields are canceled out at the center area. It is less than 0.1 [mT] inside the circle with 100 mm diameter, and it is as small as the geomagnetic field.

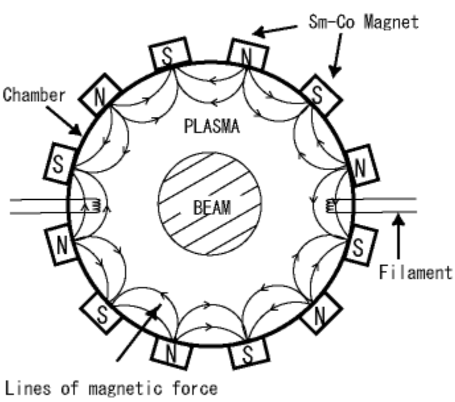

Fig. 2 Cross section of vacuum chamber

The cusp field confines the first electron emitted from the filaments, and increases efficiency of ionization [4]. It can make possible to produce plasma even at low pressure, 1.0×10^{-5} [Torr], and quiet plasma is produced around the center of the chamber.

3. Measurement of plasma

Single probe is used for measuring of plasma.

Fig. 3 Photograph of the probe

The probe consist of molybdenum wire with 0.4 mm diameter and the length of 4 mm, it is shown in Fig. 3. Molybdenum is used to prevent second electron emission from the probe surface [5,6]. The probe is inserted to plasma from a sidewall port. Plasma density, Ne, and electron temperature, Te, are estimated from the current-voltage characteristics. Argon gas was introduced, and the thermionic filaments are biased at –60 [V]. The probe is positioned at center of the chamber. The results, which are obtained for each neutral pressure, are shown in Table I. Here, the P is Ar gas pressure, and Vs is plasma potential.

Table I. Characteristic of plasma of CALM2

P (Torr)	2.0×10^{-4}	3.4×10^{-5}
Te (eV)	2.2	2.9
Ne (m^{-3})	4.3×10^{-13}	1.9×10^{-13}
Vs (V)	9.3	9.6

4. Summary

An experimental device, CALM2, was set up. The multi-pole magnetic device is operated, and plasma is produced. The first plasma is measured using a single probe, and the electron temperature, density, and plasma potential are obtained. An electron gun that produces electron beam will be prepared, near future. Research of electron plasma waves will be carried out by injecting the electron beam to the plasma. Trapping and non-linear behavior will be investigated in the observation of wave packets.

5. References

[1] R. J. Briggs, *in: A. Simon, W.B. Thomson (Eds.), Advances in Plasma Physics*, *vol. 4*, Interscience, New York, 1971, p.43.

[2] T. Takeda, K. Yamagiwa: Phys. Lett. **A339** (2005) 118.

[3] T. Takeda, K. Yamagiwa: J. Plasma Fusion Res., **81** (2005) 120.

[4] K.N. Leung, Noah. Hershkowitz, R. MacKenzie: Phys. Fluids, **19**, No.7, (1976) 1045.

[5] Shinriki Teii: *Basic Engineering of Plasma (enlarged edition)* , *プラズマ基礎工学増補版* (Uchida-roukakuho, Tokyo, 1997) Chap.3, p.125.

[6] H. Amemiya, M. Wada, H. Toyoda, K. Nakamura, A. Ando, K. Uehara, K. Oyama, O. Sakai and K. Tachibana: J. Plasma Fusion Res., **81**, No.7 (2005) 482.