Decrease of the Plasma Potential at the Electron Cyclotron Resonance in a Magnetic Mirror Field.

G. P. Galvão and S. Aihara

Instituto de Fisica Gleb Wataghin, Universidade Estudual de Campinas
13.100 Campinas, SP, Brazil

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It is well known that a radiofrequency electric field (referred as RF EF) in a magnetic mirror field can produce a hot electron plasma when the condition of electron cyclotron resonance (referred as ECR), including the fundamental resonance and the harmonic resonance, is satisfied (1-6).

In nonuniform magnetic-field geometry, hybrid combinations of the static magnetic field and RF EF have been investigated to suppress the loss rate and to heat the plasma (7).

Microwave transmission measurements verify microwave amplification by weakly relativistic electrons with energy less than 20 keV, gyrating in a tenuous plasma confined in a magnetic field (8).

Also, ECR heated plasmas have been used to produce intense beams of multiply charged ions through either single-shot collisions or multistage ionization (9).

Recently, it has been observed that when the sheath potential in a Tokamak system is reduced by electron injection, the metallic impurities, whose control is essential for fusion reactions, are suppressed (10).

Although there are many papers, few of them give clear observations of the variation of plasma potential at ECR. We have therefore examined the relation between plasma potential and RF EF at ECR and observed that the plasma potential decreases at resonance. This phenomenon could be applied to control both the plasma poten-
DECREASE OF THE PLASMA POTENTIAL ETC.

The experiments have been made on the variations of plasma potential by RFEF in a magnetic mirror field. Argon, nitrogen and helium plasmas have been produced by RFEF in a cylindrical glass tube (diameter $2R = 3.2$ cm, length 40 cm with metallic end plates connected electrically to the ground. The magnetic coil assembly consists of 4 air core coils: 2 coils in the middle produce a magnetic-field intensity $B(0)$ at midplane and the other 2 coils constitute the magnetic mirror and control the mirror ratio (max 6). The RF power, whose frequency range is between 50 MHz and 90 MHz has been obtained by a ceramic tube amplifier operating with output power up to 0.6 kwatt in continuous-wave mode. The heart of the RF coupling device with plasma has been either a 6 turn coil or a couple of copper plane electrodes connected to a coaxial transmission line. The RFEF used to ignite and heat the plasma is almost perpendicular to the static magnetic field in both cases of RF coupling devices. Plane Langmuir probes movable axially and radially are used to measure the spatial distribution of the electron density $n_e$, the electron temperature $T_e$ parallel to the magnetic field, and the plasma potential $V_p$. The Langmuir probe signals are fed to a d.c. measurement circuit with low-pass filter. Temporarily, an electron beam source at one end of the tube has been used to confirm the measurement of the plasma potential. The vapor pressure of the gas is controlled from $2 \cdot 10^{-4}$ Torr to $2 \cdot 10^{-2}$ Torr. Most of the experiments have been carried out at a pressure of $2 \cdot 10^{-3}$ Torr, since at a pressure higher than $5 \cdot 10^{-3}$ Torr the ECR effects are not observable. The intensity $E_0 \approx 0.5$ V/cm of the RFEF in the plasma at the midplane has been determined by using a calibrated-loop antenna with a coaxial cable.

According to the Langmuir probe characteristics (voltage-current relation), we can obtain the value of $n_e$, $T_e$ and $V_p$. However, since the radiofrequency $\omega_{RF} (= 2\pi f_{RF})$ is lower than the electron plasma frequency, we should have to correct the probe characteristics. Here, let us try to obtain the corrected value of a floating potential $V_f$ for example. When a RFEF voltage $V_{RF}$, which is of the order of $E_{RF} R$, is applied to the probe in the plasma, the floating potential falls from $V_f(0)$ to $V_f(V_{RF})$.

In the case of a Maxwellian electron energy distribution the variation $\Delta V_f$ of the