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Double layer formation by electron cyclotron resonance heating in inhomogeneously magnetized plasmas with high-speed ion flow

Kazunori Takahashi[1]; Toshiro Kaneko[1]; Rikizo Hatakeyama[1]

[1] Dept. Electron. Eng., Tohoku Univ.

Formations of field-aligned potential structures are important issues relating to laboratory and space plasmas, and fusion plasmas, e.g., the generation of high-energy electrons in auroral region and the formation of the barrier confining high-energy ion in tandem mirror devises. In past studies, it was reported that a potential structure reflecting an ion flow is formed by electron cyclotron resonance heating (ECRH) in an inhomogeneously magnetized plasma. It is conjectured that the height of the potential structure is determined by the ion flow energy from the plasma source. However, it has not been experimentally evidenced so far. We have developed novel plasma source, which is suitable for ion flow energy control, for use in investigation of the effects of the ion flow energy on the potential structure. In this paper, we report the formation of double layer enhanced by ECRH and the effects of the ion flow energy on the double layer in conversing magnetic-field configurations.

The experiments are performed in the QT-Upgrade machine of Tohoku University, which has a cylindrical vacuum chamber of about 450 cm in length and 20 cm in diameter. An inhomogeneous magnetic-field configuration can be formed by two parties of solenoid coils. A steady-state argon plasma with ion flow energy is injected from a low magnetic-field area and a microwave (frequency: 6GHz, power: 50 W) pulse is excited by using a horn antenna. The field-aligned profiles of electron density, temperature, and space potential are measured at 0.03 msec after the microwave injection by using a movable Langmuir probe. As a result, the electric double layer is clearly observed to be formed near the ECR point, because the electrons accelerated in the direction perpendicular to the magnetic-field lines are reflected by the magnetic mirror and the ions penetrate there. It is obviously demonstrated that the potential height is raised by the ion flow energy. Our measurements of the ion energy distribution function indicate that the potential height is self-consistently determined so as to satisfy the charge neutrality condition in the high magnetic-field area.