§22. Build-Up of Radial Electric Field in an Internal Coil Device with a High Temperature Superconductor

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Relaxation phenomenon is playing an important role in various aspects of magnetic confined plasmas, e.g., the reversed-field-pinch plasma is a self-organized state in which the plasma current becomes parallel to the magnetic field. This means that the relaxation between the electron flow (plasma current) and the magnetic field takes place.

While, plasma flow (i.e., ion flow) is another of key parameters in understanding plasma dynamics. A plasma, evolving under strong coupling of the velocity and magnetic fields, may self-organize into stable macroscopic structures that are not accessible by a flow-less plasma. Recently a relaxation theory including the plasma flow has been developed by Mahajan-Yoshida, and a new relaxation state has been identified.

To study a self-organized structure with strong plasma flow, we have introduced an internal coil device. By introducing a radial electric field with appropriate methods discussed later, we could drive a toroidal plasma flow given by $V_t = E_r / B_p$. Going away from the internal coil, the poloidal magnetic field decreases, resulting in the increase of the plasma flow velocity, if the radial electric field changes slower than the magnetic field. We expect to confine a high beta plasma by utilizing this fast plasma flow.

The internal coil device Mini-RT is equipping a levitated ring with a HTS coil, where the major radius of the HTS coil is 0.15 m and the coil current is 50 kAturns. Typical magnetic configuration is shown in Fig. 1, where The magnetic field strength near the floating coil is around 0.1 T, and the plasma production with 2.45 GHz Electron Cyclotron Heating is planned.

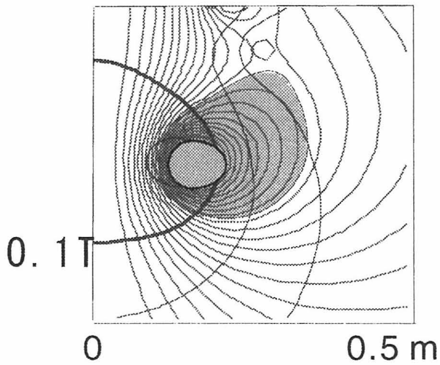

Fig. 1 Typical magnetic field configuration of the Mini-RT device.

In order to build up the radial electric field in the plasma, we are preparing several techniques. Let us remind that the direct orbit loss of fast ions at the edge pedestal region might be one candidate to trigger an H-mode transition, in relation with the build-up of the radial electric field. Here we consider the utilization of direct orbit loss of high energy electrons produced by ECH, because the ECH could produce high energy electrons more than a few tens keV. The high energy electrons would escape from the magnetic surface through the separatrix region due to its large Larmor radius. This might yield a bulk plasma to non-neutralize.

The orbits of high energy electrons have been calculated. Figure 2 shows the orbit of high energy electron only with the perpendicular energy of 10 keV produced by the ECH, where electron is launched at the electron cyclotron resonance position (around (R,Z) ~ (0.161m, 0.088m); i.e., Bp = 0.0875T), which corresponds to the magnetic surface crossing the midplane at R=0.32m. The electron is escaping through the magnetic field line outside of the separatrix, resulting in an orbit loss of high energy electron. Here we should remark that the initial position is sufficiently inside of the separatrix, because the magnetic surface of the separatrix is located at R=0.347 m (at Z = 0 m).

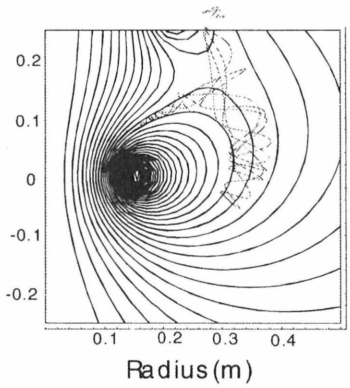

Fig. 2 The orbit of high energy electron with 10keV.

The orbit loss depends on the initial electron energy, as well. Figure 3 shows the electron energy confined in the magnetic surface as a function of the magnetic surface at the midplane. Approaching the separatrix position, the maximum energy of confined electrons decreases drastically. We could, therefore, expect that the radial electric field might be produced at the outer region of the plasma column, if the ECH could produce the high energy electrons with the energy of more than 10 keV.

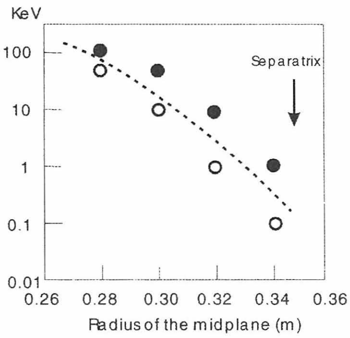

Fig. 3 Maximum energy of confined electrons.