§6. Confinement Improvement with Drift-Orbit-Optimization in CHS

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Confinement improvement was studied in CHS for the inward shifted configuration where the drift orbits of deeply trapped particles coincide with the magnetic surfaces. The MHD property of such a configuration was discussed already in the previous report. The effect of confinement improvement was studied experimentally by using ECH plasmas with plasma parameters in the low collisionality regime. Beta values of these plasmas are of the order of 0.1 % and the magnetic field configuration is almost the same as the vacuum configuration. The radial structure of major ripple components is shown in Fig. 1 for the optimized configuration with R_{ax} = 87.7 cm. A mirror ripple component (poloidal mode is zero) becomes larger at the magnetic axis in the R_{ax} = 87.7 cm configuration compared with the standard configuration with R_{ax} = 92.1 cm. Because, in central region of the standard configuration, all ripples are considerably small compared to the toroidicity, the transport in the central region is supposed to be dominantly the same as that for an axisymmetric torus (no helical effect). The transport due to helical ripples might be important in the region of r/a = 1/3 ~ 2/3. For the region from a half radius to the boundary, it is usually observed that the anomalous transport becomes increasingly dominant.

Series of ECH discharges were made for several R_{ax} parameters between the optimized configuration and the standard one. 200 kW of heating power at 53 GHz frequency was used with good microwave beam focusing at the magnetic axis. The magnetic field strength on the axis was 0.95 T. The single-path absorption is estimated to be about 70 % for the typical plasma parameters in the experiments. The plasma density was set at 5 - 6 × 10^{12} cm^{-3} to ensure the collisionless condition.

Figure 2 shows the plasma diamagnetic energy normalized by the plasma volume and the central electron temperature as a function of the position of the magnetic axis R_{ax}. The normalized plasma energy increased as the R_{ax} is shifted inward which demonstrates the confinement improvement. But it started to drop before getting to the final optimized configuration R_{ax} = 87.7 cm. On the other hand, the increase of the central electron temperature was observed only for R_{ax} = 91.1 cm and it decreased for the further inward shift.

It is expected that the neoclassical transport in the central region of the R_{ax} = 92.1 cm configuration is dominated by the tokamak-like banana particle motions. But in the region near the half radius, transport caused by the helical ripples becomes more important. The increase of the global confinement for the inward shifted configuration comes from the improvement of transport near the half radius because the contribution of this area is much larger than the one from the central region. The configuration optimization had a large effect on the transport in this region by suppressing the ripple diffusion of trapped particles caused by the drift motion. On the other hand, in the central region, the helical ripple diffusion is not the dominating diffusion process for the R_{ax} = 92.1 cm configuration. When the magnetic axis is shifted inward, ripple on the axis is increased as shown in Fig. 1. It is expected that the additional transport appeared due to the increased ripple near the magnetic axis. This might be the reason why the central electron temperature decreased for the inward shifted configuration.

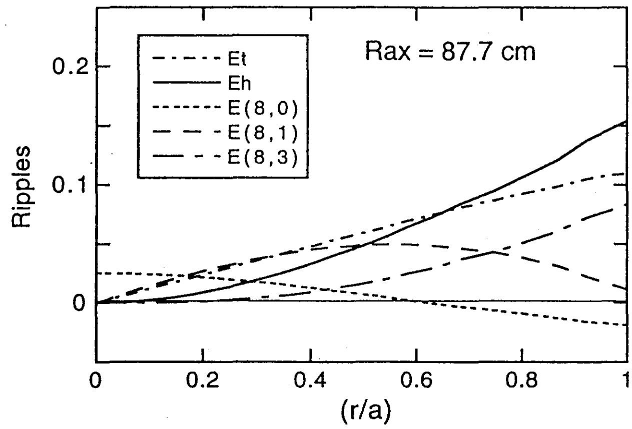

Fig. 1. Profile of magnetic field ripple structure for drift-orbit-optimized configuration. Selected components are E_t : toroidicity, E_h : helical ripple (8, 2), mirror ripple (8, 0), side bands (8, 1) and (8, 3).

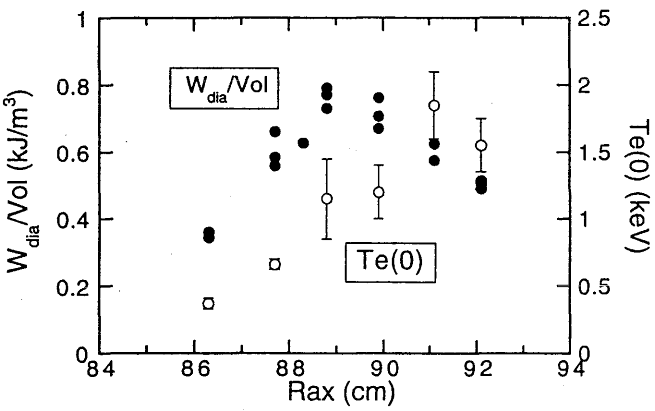

Fig. 2. Dependence of volume normalized energy and central electron temperature on the position of magnetic axis R_{ax}.