§11. Drift-orbit-optimization with Inward-shifted Configuration

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In CHS, it is possible to coincide the magnetic surfaces with the drift orbits by shifting the magnetic surfaces to the inward side of the torus with the vertical field control. However, theories predict that the stability is lost when the magnetic surfaces are shifted inward with loss of magnetic well and reduction of magnetic shear. It is believed that there is no compatibility of the drift-orbit-optimization and the MHD stability for Heliotron/Torsatron systems and such a configuration has not been considered seriously.

Experiments have been done in CHS to examine the confinement and MHD stability of the drift-orbit-optimized configuration. ECH plasmas were used for the confinement study of low collisionality plasmas and NBI plasmas were used for the MHD stability study with higher beta values. Temperature and density profiles were measured for all discharges in order to put into the MHD stability analysis since the pressure profile is very important for the evaluation of the stability.

Figure 1 shows the beta values and the plasma positions of selected discharges. The plasma position is defined as an averaged major radius of the last closed magnetic surface. The thick solid line shows the ideal interchange mode stability boundary given by the Mercier criterion (high mode number criterion). The left side of the line is the unstable region. The thick dotted line gives a stability boundary for low-mode instabilities. The drift-orbit-optimization is realized with the plasma position of 90 cm which is deeply in the Mercier unstable region. The square and circle points are experimental data points with NBI and ECH, respectively. They were found to be stable discharges though the Mercier stability was violated. There is a first stability region for very low beta values given by the magnetic shear. However, such a region exists with extremely low beta values, even lower than those of ECH discharges shown in the figure.

Three triangles are taken from the high beta experiments in CHS. An example of the plasma movement is shown by the arrow for the discharge which became Mercier stable as the plasma beta increased. The Mercier stability generally becomes better when the plasma beta increases because of the outward shift of the plasma position and the creation of a magnetic well, due to the Shafranov shift. Figure 1 shows that discharges in the inward shifted configuration of CHS were already stable even in the lower beta region where theories predict instability and a route to a second Mercier stability is open.

Figure 2 shows magnetic fluctuations measured for NBI discharges shown in Fig. 1 as a function of the plasma beta. The magnetic fluctuations of CHS plasmas are generally larger for the inward shifted discharges than for the outward shifted ones for $R_{00} > 92$ cm. However they did not increase for those discharges ($R_{00} < 92$ cm) even though the Mercier stability condition became worse as the plasma position was moved inward.

The improvement of confinement in the drift-orbit-optimized configuration was observed for ECH plasmas with low collisionality. The total energy and temperature profiles were compared for plasmas with the density of 4×10^{12} cm^{-3} and the electron temperature of 1 keV for those configurations shown in Fig. 1. As the plasma position was shifted inward, the global confinement was improved and the temperature gradient became larger.

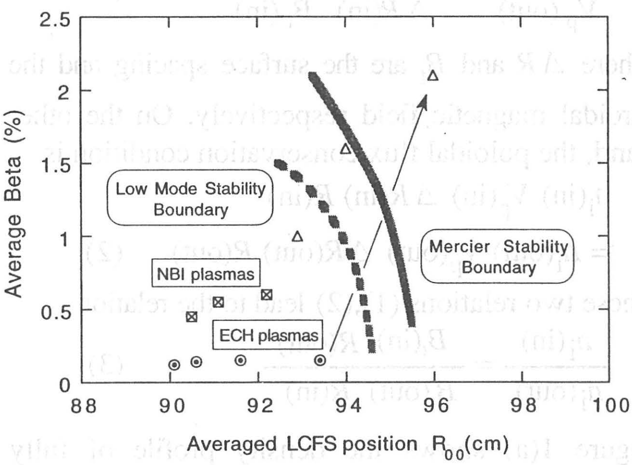

Fig. 1. Interchange stability diagram of CHS plasmas

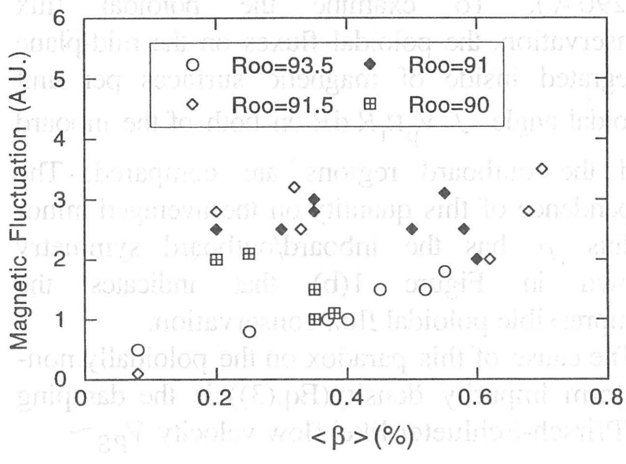

Fig. 2. Magnetic fluctuations in inward shifted configurations