§19. Effects of Net Toroidal Current Profile on Mercier Criterion in Heliotron Plasma

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In the heliotron configurations, net toroidal current is not needed for the generation of the confinement magnetic field. However, substantial net toroidal currents over 100kA have been observed in the recent discharges in the LHD. Thus, in this study, the effects of the variation in the net toroidal current profile on the Mercier criterion are investigated in an LHD configuration with the vacuum axis position of $R_{ax} = 3.6$m under the free boundary condition. Both hollow and peaked current profiles are examined, which correspond to the bootstrap and the Ohkawa currents, respectively.

At first, as one of the equilibrium properties, it is found that the plasma column and the magnetic axis are shifted horizontally by the net toroidal current because the effective vertical field is changed. The direction of the shift depends on the direction of the current, but the amount of the shift is independent of the profile.

In the case of the subtractive current which decreases the rotational transform(ι), the equilibrium is more stable than the no net current equilibrium, although the plasma axis is shifted inward by the current itself. This is because the Shafranov shift is superior to the axis shift by the current and the magnetic well is enhanced.

In the case of the additive current which increases ι, the stability can be improved as the peak position of the current density varies from the axis to the peripheral region in the hollow current density profile. For example, the stability is improved for the hollow current density given by $J(\rho) = J_0(\rho^2 - \rho^4)$ in the region near the $\iota = 1/2$ (Fig.2) compared with the currentless case (Fig.1). This is due to the enhancement of the magnetic shear near the magnetic axis.

Figure 3 shows the stability diagram for the case of the combination of the subtractive current peaked at the axis and the additive hollow current under the condition that the total current should be zero. As is shown in Fig.3, the interchange mode is stabilized substantially by comparing with the currentless case. Therefore,, the Mercier mode can be stabilized by the net current depending on the profile, even if the total current is zero.

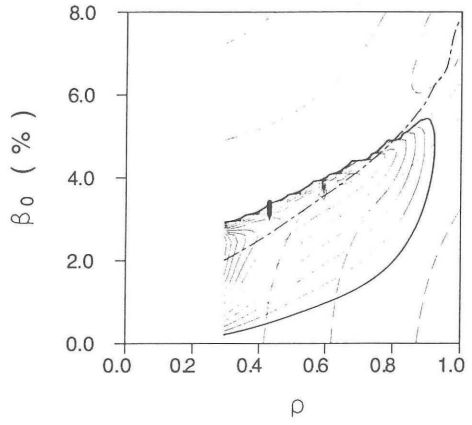

Fig.1 Contour of Mercier instability quantity for the currentless case. The 3rd dashed line from right shows the position of $\iota = 1/2$.

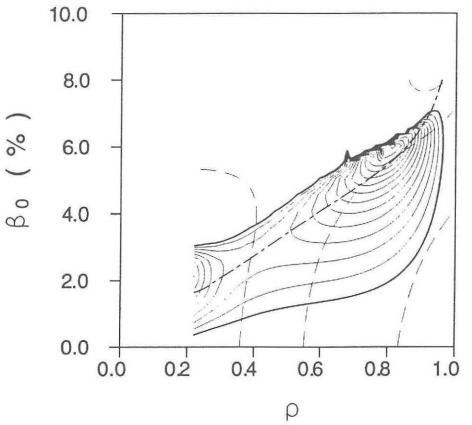

Fig.2 Contour of Mercier instability quantity for the hollow current density.

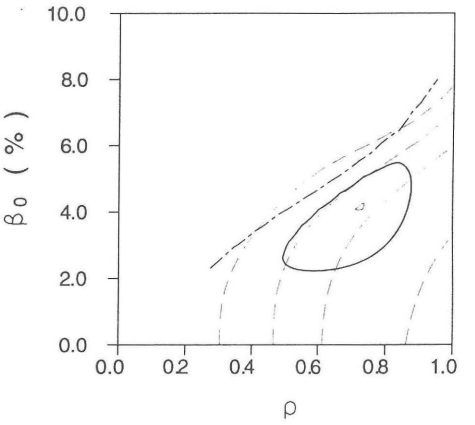

Fig.3 Contour of Mercier instability quantity for the combined current density.