§2. MHD Properties of LHD with Multi Layer Helical Coils

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Each helical coil in the LHD is composed of three layers which are called the outer (O) , the mid (M) and the inner (I) layers. In the standard configuration corresponds to $\gamma_c = 1.25$, all three layers are used for generating the confinement magnetic field, where $\gamma_c = 1.25$. If only the O-layer is used, the radius of the helical coil becomes large and γ_c increases to 1.38, while γ_c decreases to 1.12 in the case of only the I-layer. The three-dimensional MHD equilibria for each combination of the layers in the helical coils are investigated with the VMEC code under the fixed boundary condition. In this study, the currentless condition is imposed and the pressure profile of $P = P_0(1-\Phi)^2$ is assumed, where Φ denotes the normalized toroidal magnetic flux.

The shift in the case of $\gamma_c = 1.38$ is larger due to the smaller rotational transform at the axis, $\iota(0)$, in the vacuum configuration than the standard case. It leads the enhancement of the magnetic well. On the other hand, the small Shafranov shift of the axis due to the large $\iota(0)$ in the vacuum configuration in the case of $\gamma_c = 1.12$ reduces the formation of the magnetic well. The gradient of the rotational transform at the peripheral region becomes steep as beta increases. In the case of $\gamma_c = 1.38$, the change of the profile is large because of the strong deformation of the flux surfaces. Hence, the significant effect of the shear stabilization against MHD instabilities can be expected in this region. In the case of $\gamma_c = 1.12$, the change of the rotational transform is small due to the small Shafranov shift of the flux surfaces, and therefore, the shear stabilization is weak. Here, we focus on the stability against the interchange mode in the equilibria with different combination of the layers by estimating the Mercier criterion. Figure 1 shows the results of the Mercier stability for the cases of γ_c =1.12, 1.25 and 1.38. In the case of standard configuration with $\gamma_c = 1.25$, the instability which is seen in the plasma column in Fig.1(b) is so weak that the equilibria may be actually stable against the ideal interchange mode. In the case of $\gamma_c = 1.38$, the unstable region completely disappears in the plasma. This is due to the stabilizing contributions of the magnetic well and the magnetic shear. On the other hand, the Mercier mode is strongly destabilized in the case of $\gamma_c = 1.12$ because both of the stabilizing effects of magnetic well and the magnetic shear are reduced. The equilibrium beta limit is also estimated as the function of γ_c, which is determined by the convergence of the iteration in the VMEC code. The configuration with the larger γ_c has the smaller equilibrium limit owing to the larger Shafranov shift.

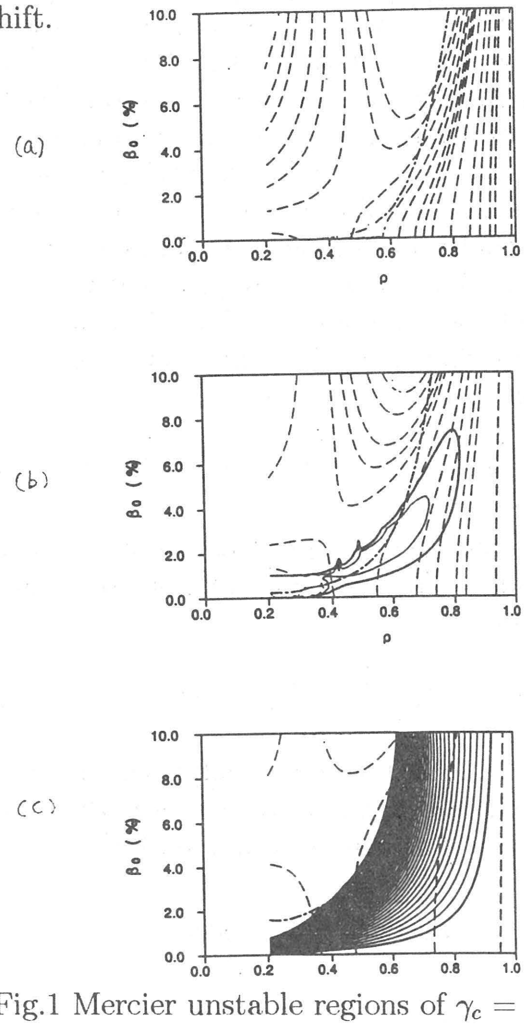

Fig.1 Mercier unstable regions of $\gamma_c =$ (a)1.38, (b)1.25 and (c)1.12.