§1. Mercier Stability Study of Free-Boundary Equilibria in LHD

Ichiguchi, K., Gardner, H.J. (Australia National University)

In the 3D equilibrium calculations under the free boundary conditions by means of the VMEC code[1], the constraint to determine the position of the plasma-vacuum boundary is crucial. The simplest constraint for the boundary may be that the total toroidal magnetic flux must be kept the value of the vacuum configuration. In this case, however, the shape of the plasma at high beta value cannot be acceptable physically because it involves the separatorix region. Therefore, another two kinds of the constraint are employed here. One is the control of the plasma position with the constant toroidal magnetic flux. In this case, the vertical magnetic field is adjusted so that the most outward point in the plane of the horizontal ellipse should be fixed for each beta value. This feed-back control is planned in the 2nd stage of the LHD experiments. The other is to set a virtual limiter at the same fixed point as that in the first constraints. As the beta value increases, the limiter peels the outer flux surface, This situation demonstrates to the destroy of the peripheral nested surfaces due to the finite beta effect.

Figures show the Mercier unstable regions in the equilibria under the above constraints and in the fixed-boundary equilibria as a reference. Here it is assumed that the pressure profile is given by $P(s) = P_0(1 - s)^2$ (s:normalized toroidal flux), and the currentless condition is imposed. Fig.1 shows that there exists a slightly unstable region under the fixed boundary condition. In the case of the position control with the vertical field, the Mercier unstable region is quite similar to that in the fixed boundary case as shown in Fig.2. It is followed that fixed-boundary equilibrium may be a good approximation of the free-boundary equilibrium controlled by the vertical field. On the other hand, it is shown in Fig.3 that the Mercier unstable region disappears in the equilibria with the virtual limiter. This is due to the stabilizing effect of the magnetic well caused by the large Shafranov shift.
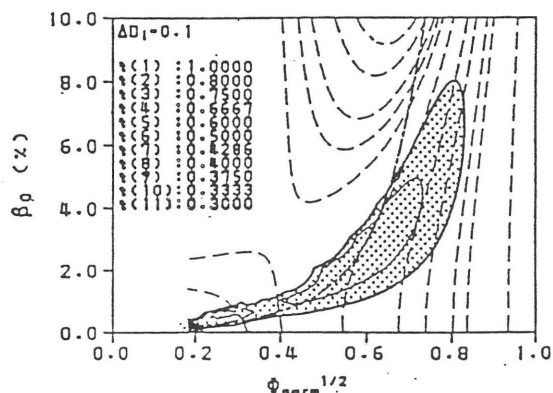

Fig.1 Mercier unstable region of LHD equilibria under the fixed boundary condition.
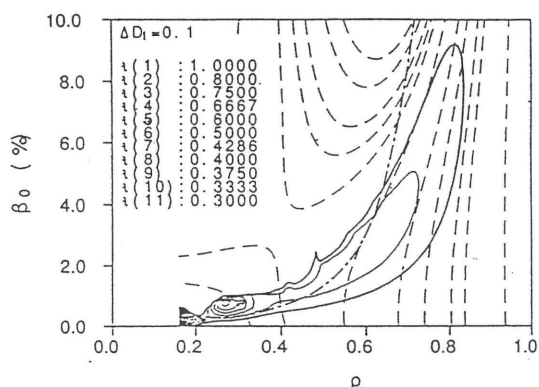

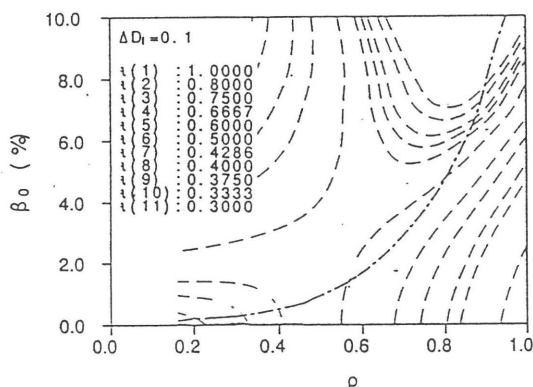Fig.2 Mercier unstable region of LHD equilibria with the feed-back control.

Fig.3 Mercier unstable region of LHD equilibria with a virtual limiter.

References
1) Hirshman S.P., et al. : Comp.Phys.Comm. 43 (1986) 143.