§6. Magnetic Island Generation in Nonlinear Evolution of Interchange Mode

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The interchange mode is one of the most dangerous MHD instability in zero-current stellarators. In the linear analysis, the eigenfunction for the poloidal magnetic flux corresponding to the maximum growth rate is an odd function in the radial coordinate. Therefore, the flux is close to zero at the resonant surface even with finite resistivity in the slab geometry. This means that magnetic islands are hardly generated spontaneously in the linear phase, not like the tearing mode.

On the other hand, significant magnetic islands can be generated in the nonlinear saturation phase of the interchange mode[1)]. Figure 1 shows the contour of the helical magnetic flux of the interchange mode with the single helicity of $n/m = 1/2$ in the cylindrical geometry. The position of the resonant surface with $\iota = 1/2$ is also indicated by the dashed line. In this case, the dominant component is the $(m, n) = (2, 1)$ mode in the whole time evolution. In the linear phase, thin islands are generated spontaneously because of the cylindrical geometry as shown in Fig.1(a). The number of the island in the poloidal cross section is the same as the poloidal mode number of the dominant component. In the nonlinear saturation phase, the number of the island is twice of the poloidal mode number as shown in Fig.1(b). This is due to that X-points are generated where the O-points are located in the linear phase.

The generation of the X-points in the nonlinear phase is related to the radial flow of the vortices due to the interchange mode. Figure 2 shows the flow pattern of the mode in the saturation phase. The flow is across the resonant surface. This pattern is almost kept in the whole time evolution. The flow pushes outward the contour of the perturbed poloidal flux contour around $\theta = 0$ and π. Then, the curvature of the contour is enhanced. The enhancement of the curvature of the contour results in the change of the perturbed magnetic field. The direction of the radial component of the magnetic field is reversed when the curvature of the contour becomes larger than $1/r$. The reverse of the radial magnetic field direction changes the O-point to the X-point in the saturation phase.

(a)

(b)

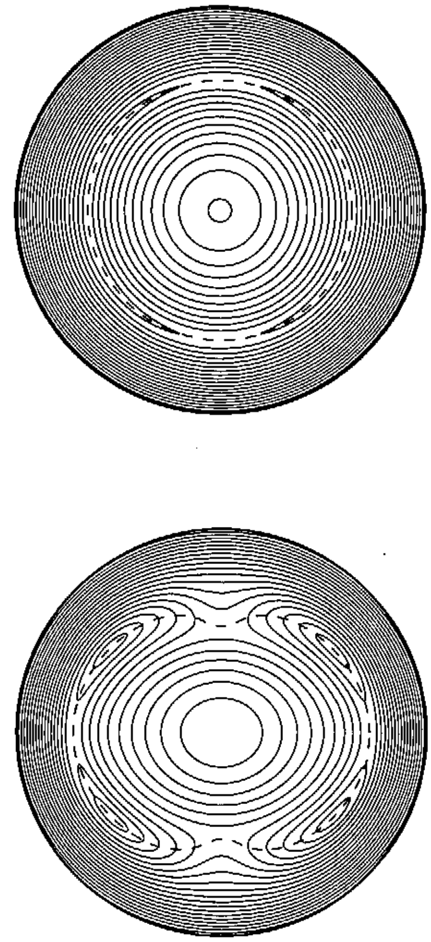

Fig.1 Contour of helical magnetic flux for $r \leq 0.8$ in (a) linear phase and (b) nonlinear saturation phase.

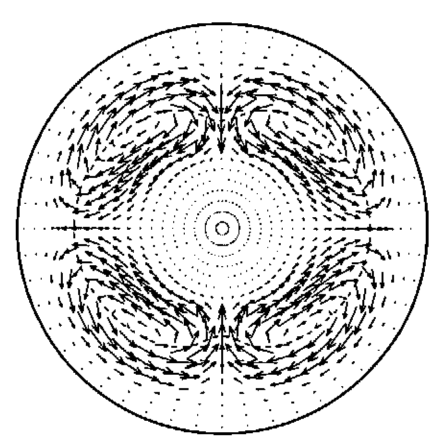

Fig.2 Flow pattern for $r \leq 0.8$.

References
1) Ichiguchi, K., et al., Nuclear Fusion **43**,(2003)1101.