§12. Interaction between Static Magnetic Islands and Resistive Interchange Modes in a Straight Heliotron Plasma with High Resistivity

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Interaction between resistive interchange mode and static magnetic islands generated by an external perturbed field in a straight LHD configuration is numerically studied. We follow the nonlinear evolution of the resistive interchange mode with single helicity by utilizing the NORM code[1)], which is based on the reduced MHD equations, and focus on the change of the magnetic islands between the initial state and the saturation state of the mode. In this analysis, the effect of the static islands is incorporated by setting a finite static external poloidal magnetic flux Ψ_b at the plasma boundary. We examine the interaction between the static islands with the mode number of $(m,n)=(1,1)$ and the interchange mode with the same mode number. We also assume a high resistivity of $S=10^4$ which generates a significant islands without the external field.

Figure 1 shows the dependence of the island width on Ψ_b. The plots of w_i and w_s show the island width at the initial state and the saturation state, respectively. The value of σ denotes the sign of the initial perturbations of the reduced MHD equations. The plots for the different σ are symmetry with respect to the origin of the graph. There is a global tendency that w_s approaches to w_i as Ψ_b increases. Depending on Ψ_b, the island width is increased or decreased by the nonlinear evolution of the interchange mode. In the case of $\sigma=-1$, $|w_s|>|w_i|$ for $\Psi_b \gtrsim -2\times10^{-4}$ and $|w_s|<|w_i|$ for $\Psi_b \lesssim -2\times10^{-4}$. The phase at a cross section can also be changed for $-4\times10^{-4} \lesssim \Psi_b < 0$. As an example of such change of the island, contours of the helical magnetic flux at the cross section of $z=0$ are shown in Fig.2 for the case where the width is decreased and the phase is changed. While the X-point is located at $\theta=\pi$ in the initial state, it is located at $\theta=0$ in the saturation state.

The change of the magnetic island can be explained by the change of the $(m,n)=(1,1)$ component of the perturbed poloidal flux. In spite of the nonlinear evolution, the component at the saturation state almost equals to the linear sum of the external component in the initial state and the component obtained by the nonlinear evolution of the interchange mode for $\Psi_b=0$. The width and the phase of the island are determined by the absolute value and the sign of the sum, respectively. In the case of $\Psi_b=-3.0\times10^{-4}$ as shown in Fig.3, the sign is changed to negative to positive and the absolute value is reduced. These changes in the poloidal flux correspond to the change in the island shown in Fig.2. By assuming that the poloidal flux part due to the interchange mode is independent of Ψ_b, we can derive an analytic expression for the island width in the saturation state, which is drawn in Fig.1 (solid lines). Good agreement with the numerical results is obtained.

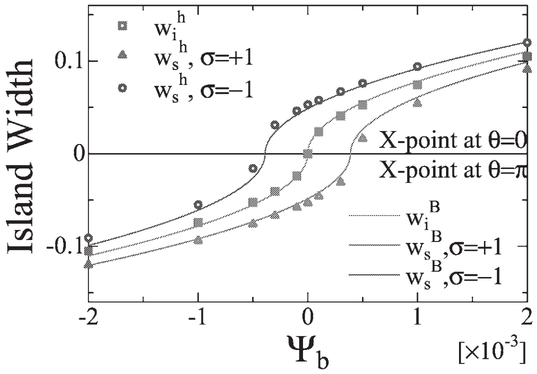

Fig. 1: Change of island width.

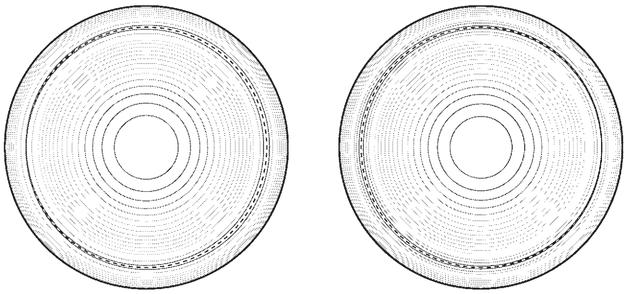

Fig. 2: Contour of helical magnetic flux for $\Psi_b=-3.0\times10^{-4}$ and $\sigma=-1$ at initial (left) and saturation (right) states.

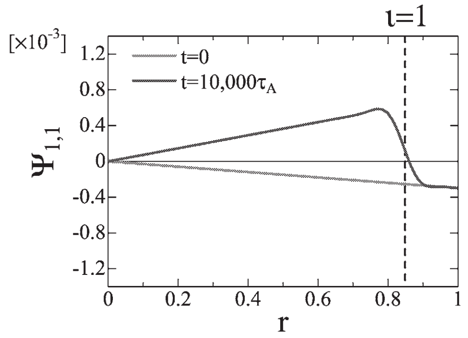

Fig. 3: Profile of $(m,n)=(1,1)$ component of perturbed poloidal flux corresponding to Fig.2.

1) Ichiguchi, K. et al., Nucl. Fusion **43**, 1101-1109 (2003).