Magnetic Islands Induced by Nonlinear Evolution of Resistive Interchange Mode

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The interchange mode is one of the crucial MHD instabilities 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 a finite resistivity. This means that magnetic islands are hardly generated spontaneously in the linear phase, not like the tearing mode. However, in the numerical study for a straight heliotron geometry, Ichiguchi et al.[1] showed that the magnetic islands can be generated in the nonlinear saturation phase of the interchange mode. In this case, the number of the islands in the poloidal cross section varies in the time evolution. Just after the linear phase, the islands of the same number as the dominant poloidal mode number of the interchange mode is generated. Later in the steady state, second harmonic islands are generated inside the dominant islands. The number of the island is twice of the dominant poloidal mode number. X-points of the second harmonic islands are located at the O-points of the dominant harmonic islands. The positions of the islands coincides with those of the local vortices induced by the interchange mode. The X-points are generated at the points where the flow direction of the vortices is the radial direction. Therefore, it is considered that a driven reconnection due to the local vortices results in the island generation. In Ref.[1], a heuristic explanation for the generation of the second harmonic islands is given. In the present paper, an analytic approach for understanding the island generation is presented. Here we assume the cylindrical geometry and the single-helicity perturbations. At first, the generation of the dominant harmonic islands is explained. It is shown that the cylindrical geometry and a high resistivity make a substantial shift of the zero-point of the perturbed poloidal flux. Next, the analysis for the generation of the second harmonic islands is discussed. An ordering for the perturbations are introduced and equations for the second harmonic perturbations are derived. The equations are solved by means of an iteration method. The comparison between the analytic and the numerical solutions is given.

[1] K. Ichiguchi, B.A.Carreras, J. Plasma Fusion Res. **SERIES 6** (2004) 589.