§2. Interchange Instability in LHD Equilibria with Magnetic Islands

Ueda, R., Watanabe, K.Y.,
Matsumoto, Y. (Hokkaido Univ.)

i) Background

In high-β LHD experiment, the low-order mode magnetic fluctuations due to the Magnetohydrodynamics (MHD) instability are observed[1]. The dependence on the β value and the magnetic Reynolds number suggests that such magnetic fluctuations are due to the resistive interchange mode. In the large aspect ratio plasma, the rapid degradation of the confinement property is observed[2], which is considered to be due to the interchange instability. A suggestion to supress the interchange instability is control of the pressure gradient utilizing the magnetic islands. In the experiment, the magnetic island is impposed aiming to flatten the pressure profile and the effect on the interchange instability is observed[3]. To validate the effectiveness of the approach, theoretical analysis is required. The purpose of this study is to clarify numerically the effect on the low-ordered interchange instability.

ii) Calculation method of equilibrium and $(m, n) = (1, 1)$ mode instability

Three dimensional equilibria with and without the magnetic island are obtained by HINT2 code[4]. The time evolution of the instability is calculated by MHD Infrastructure for Plasma Simulation (MIPS) code[5]. MIPS code utilizes the equilibrium obtained by HINT2. However, the original MIPS procedure poses a problem in that we cannot investigate the specified single Fourier mode instability. To analyze the low-ordered unstable Fourier mode, we utilize a tequnique which can construct the initial perturbation with single Fourier mode[6]. The investigation is focused on the $(m, n) = (1, 1)$ mode. Here, m is the poloidal mode number and n the toroidal mode number, respectively.

iii) Equilibrium pressure and linear growth rate of the $(m, n) = (1, 1)$ mode instability

Figure 1 shows the pressure profiles of the equilibrium on the vertically elongated poloidal cross section for the with and without the magnetic island. For the equilibrium without the magnetic island (dashed line), the pressure profile does not have flattening structure. On the other hand, for the equilibrium with the magnetic island (solid line), the flatteing pressure profile can be seen in the island region. In this figure, the magnetic island exists in the vicinity of $R = 3.5$m and the island width normarized by minor radius is $w/a = 0.22$. Figure 2 shows the growth rate of the $(m, n) = (1, 1)$ mode as a function of the normarized island width for the linear growing phase. It can be seen that the $(m, n) = (1, 1)$ linear growth rate does not largely depend on the magnetic island width.

iv) Summary and Future works

We investigate the effect of the pressure profile flattenings due to the magnetic islands on the interchange instability. The linear growth rate of $(m, n) = (1, 1)$ mode does not largely depend on the magnetic island width. As a future work, the reason linear growth rate does not depend on the pressure gradient on the resonant rational surface will be investigated.

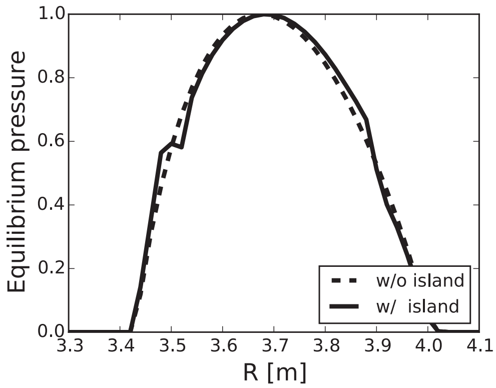

Fig. 1: Equilibrium pressure profile with magnetic island (dashed line) and without island (solid line).

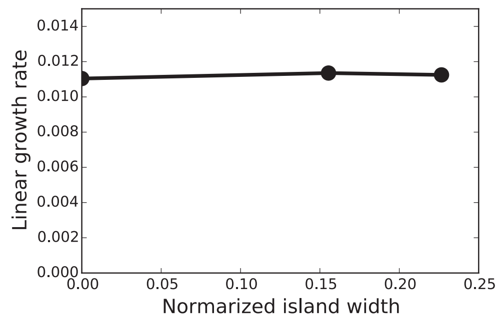

Fig. 2: Linear growth rate of $(m, n) = (1, 1)$ interchange mode as a function of normarized magnetic width.

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3) Yamada, H. *et al.*: Plasma Phys. **50** (2010) 480.

4) Suzuki, Y. *et al.*: Nucl. Fusion **46** (2006) L19.

5) Todo, Y., *et al.*: Plasma Fusion Res. **5** (2010) S2062.

6) Ueda, R. *et al.*: Plasma Fusion Res. **8** (2013) 2403157.