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Stabilization Analysis of Neoclassical Tearing Mode in Fusion Plasmas
核融合プラズマにおける新古典ティアリングモードの安定化解析

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For stabilization of neoclassical tearing mode (NTM), Electron Cyclotron Current Drive (ECCD) is used. The change of the EC control efficiency depends on EC injection width and the lag in the EC injection phase from O-point of magnetic island. The time variation of magnetic island is described by the modified Rutherford equation. In this work, NTM by ECCD is analyzed using 1.5-dimensional transport code TOTAL. NTM can be stabilized with less EC current when the lag in the EC injection phase from O-point of magnetic island is smaller and EC injection width is narrower.

1. Introduction

For the achievement of high beta value in tokamak fusion reactors, it is important to control magnetic islands produced by neoclassical tearing mode (NTM) and to suppress plasma confinement degradation [1]. For stabilization of NTM, Electron Cyclotron Current Drive (ECCD) is used. Figure1 shows the model of EC modulation in phase with island rotation. The stabilization efficiency of the EC current localization changes by EC injection phase, position and width. However, how much the efficiency of the EC current change by these values is not clarified.

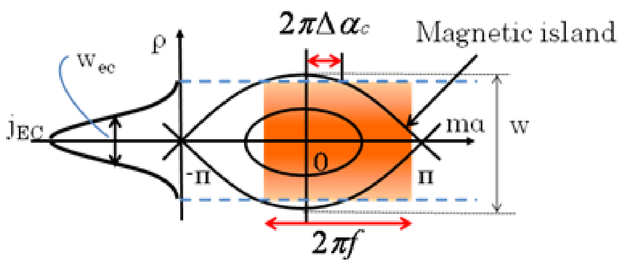

Fig.1 The model of EC modulation in phase with island rotation

2. Numerical model

In this work, plasma parameter change due to NTM is analyzed and the NTM control by ECCD was studied using 1.5-dimensional transport code TOTAL. The anomalous transport model used here is GLF23 that can simulate H-mode plasma. The plasma equilibrium is solved by the Apollo code. The time variation of magnetic island is described by the modified Rutherford equation [2].

$$\frac{dw}{dt} = \Gamma_{\Delta'} + \Gamma_{BS} + \Gamma_{GGJ} + \Gamma_{pol} + \Gamma_{EC} \qquad (1)$$

Where $\Gamma_{\Delta'}$ is the classical stability index defined as the logarithmic jump of the radial magnetic perturbation across the rational surface[3]. The terms Γ_{BS}, Γ_{GGJ}, Γ_{pol} and Γ_{EC} represent effects of the bootstrap current, the field line curvature[4], the ion polarization current[5] and EC current drive.

3. Numerical result

The change of the EC control efficiency η_{ec} by the lag in the EC injection phase from O-point of magnetic island $\Delta\alpha_c$ is shown in Fig.2, whrere η_{ec} is given as follows [6]

$$\eta_{EC} = \frac{\int d\rho \oint \frac{d\alpha}{2\pi} cos(m\alpha) \langle\langle j_{EC} \rangle\rangle}{\int d\rho \oint \frac{d\alpha}{2\pi} \langle\langle j_{EC} \rangle\rangle} . \qquad (2)$$

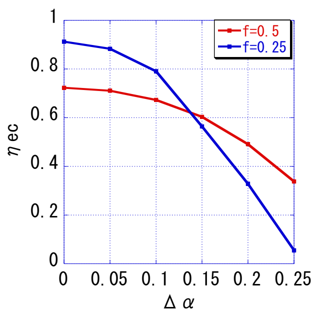

Fig.2 EC current efficiency η_{ec} to a function of EC injection phase $\Delta\alpha_c$

For the smaller lag in the EC injection phase, η_{ec} becomes larger value. In the case of f=0.5(half of the magnetic island), η_{ec} is about 0.7 when $\Delta\alpha_c$ is nearly equal to zero. On the other hand, for f=0.25(narrower EC injection width case), a large value η_{ec} =0.9 can be achieved. Therefore, NTM can be stabilized with less EC current if the lag in the EC injection phase is smaller and EC injection width is narrower.

Temporal evolution of magnetic island width in ITER parameter (major radius: 6.2[m], minor radius: 2.0[m], plasma current: 15.0[MA], troidal field: 5.3[T]) is shown in Fig.3. EC current is Iec=80[kA], and EC injection width is (a)f=0.5, or (b)f=0.25.

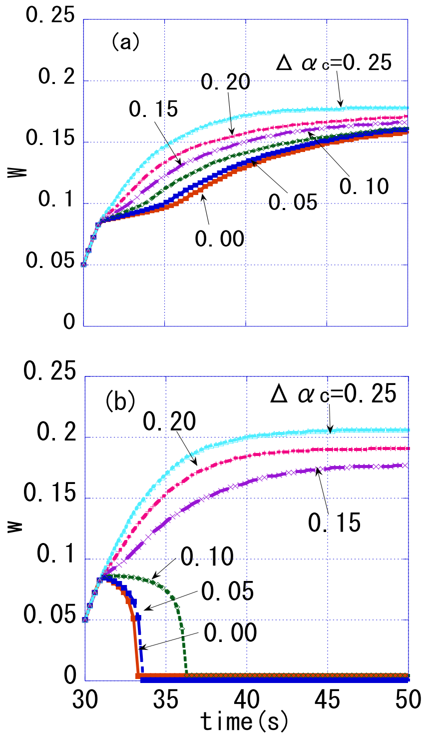

Fig.3 Temporal evolution of magnetic island width W for EC injection width (a)f=0.5 and (b)f=0.25

According to Fig.2, the EC control efficiency is a higher value when the lag in the EC injection phase from O-point of magnetic island is smaller and EC injection width is narrower. So NTM can be stabilized when $\Delta\alpha_c \leqq 0.10$ and f=0.25.

The temporal evolution analysis of central electron temperature and the stabilization effect of non-resonant helical field application will also be reported in the conference.

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