§37. MHD Stability of the Current Carrying Plasma with Finite β in LHD

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In Heliotron plasma, it is not concerned with the current driven instabilities because the plasma does not need the plasma current to make its confinement magnetic field. In the actual experiment, there are some kinds of currents like the bootstrap current and Ohkawa current. Therefore, it is worthwhile to study the characteristics of stabilities of the current carrying plasma. The MHD stability analysis with the low-n ideal 3-D MHD stability code TERPSICHORE[1] has been carried out to examine the characteristics of the current carrying plasma with finite β. The equilibrium calculated with VMEC code[2] has the parameters of the magnetic axis ($R_{\rm ax}$=3.75m) and coil pitch parameter ($\gamma_{\rm c}$=1.15), in which the configuration has higher rotational transform compared with the standard one. For an equilibrium modeled, the profiles of the plasma current density and the pressure are assumed as $j(\rho)=j_0(1-\rho^2)$ and $\beta(\rho)=\beta_0(1-\rho^2)(1-\rho^8)$, respectively. The fixed boundary condition is adopted for the analysis. Figure 1 shows a result of calculation for β_0=0.5% and $I_{\rm p}$=55[kA/T]. The profile of the rotational transform $\iota/2\pi$ goes up by the effects of the finite β and $I_{\rm p}$(Fig1(a)). The m/n=1/1 mode is destabilized(Fig1(b)) and the current driven term dominates the potential energy((Fig1(c))). The unstable region of m/n=1/1 mode is shown in Fig.2 as a β_0 vs. $I_{\rm p}$ space, which indicates that the plasma is destabilized in the high β and/or high $I_{\rm p}$ region. In case of the higher $I_{\rm p}$ region ($I_{\rm p}$>40[kA/T]), the current driven term is dominant in the potential energy while the pressure driven term is dominant in the case of lower $I_{\rm p}$ ($I_{\rm p}$<40[kA/T]). In the lower $I_{\rm p}$($I_{\rm p}$<40[kA]) and finite beta (1.0[%]<β_0<3.0[%]) plasma , the plasma current contributes to making of the pressure driven mode unstable.

References

1) W. A. Cooper, Plasma phys. and Controlled Fusion 34, (1992) 1011
2) S. P. Hirshman, W. I. Van Rij, and P. Merkel, Comput. Rhys. Commun. 43, (1986) 143

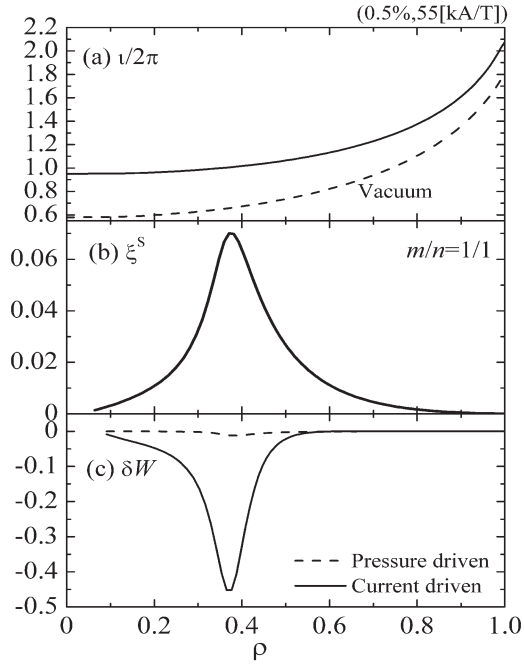

Fig. 1: Profile of (a)rotational transform, (b)Fourier amplitude of m/n=1/1 mode and (c)Potential energy.

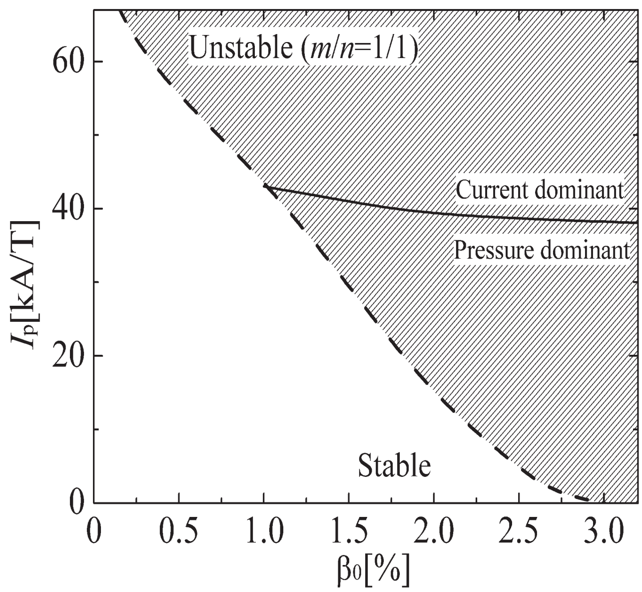

Fig. 2: Unstable region for m/n=1/1 mode in β_0 vs. $I_{\rm p}$ space