§ 19. Ideal MHD Analysis on LHD Plasma with Large Toroidal Current

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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. It is worthwhile to study the characteristics of stabilities of the current carrying plasma. Low-n ideal MHD analysis on LHD plasma with large toroidal current is carried out using TERPSICHORE[1], and the characteristics are studied.

The equilibrium calculated by VMEC code[2] has the parameters of the magnetic axis (R_{ax}=3.75m) and coil pitch parameter (γ_c=1.25). This configuration is stable against the pressure driven instabilities over the wide range of β. Three kinds of the current density profiles are adopted. ① $j=j_0(1-\rho^2)$ (parabolic) ② $j=j_0(1-\rho^4)$ (broad) ③ $j=j_0(1-\rho^2)^2$ (peaky) The parabolic profile is mainly analyzed here. Direction of the current is defined as positive in the direction to which the rotational transform is made to increase. The profile of the rotational transform is varied by the value of the current as shown in Fig.1. In case of current free plasma (Fig.1(a)), the rotational transform has some rational surfaces of $\iota/2\pi$=1/2, 2/3, 1/1. On the other hand, large current case, that rational surfaces disappear (Figl.(c)).

Figure2 shows the growth rate γ of some modes against the plasma current I_p[kA/T]. All modes appear around the I_p=113[kA/T] region. The value of I_p at the time of the modes appearing depends on the current profile. In case of broad profile, modes appear at I_p>80[kA/T]. On the other hand, only m/n=1/1 mode is destabilized at I_p>123[kA/T] in peaky profile case. Increasing the plasma current, the growth rates of higher modes (m/n=2/2, 3/3, 4/4, 5/5) decrease and finally disappear, and only m/n=1/1 mode survives. The minimum rotational transform is also shown in Fig.2. The rational surface of $\iota/2\pi$=1.0 disappears at I_p>113[kA/T]. The m/n=1/1 mode exists even in that the rational surface of $\iota/2\pi$=1.0 disappears. This means that the m/n=1/1 mode can be destabilized by plasma current as the non-resonant mode.

Low-n ideal MHD analysis on LHD plasma with large toroidal current and zero-β is carried out using TERPSICHORE. The toroidal current has the role of controlling the profile of the rotational transform. The result of the analysis shows that the current driven instability with m/n=1/1 mode appears in the equilibrium without the rational surface of $\iota/2\pi$.

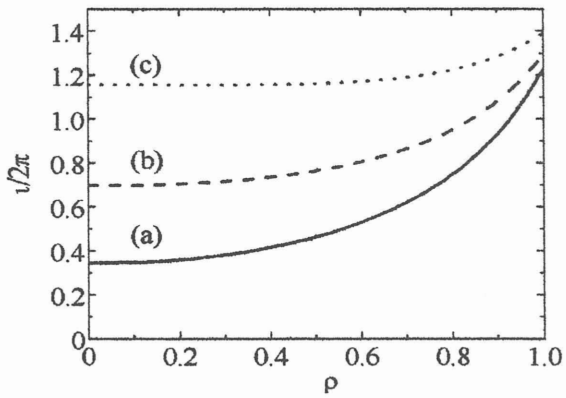

Fig. 1: Profile of rotational transform of (a) current free (solid) and (b)I_p=67[kA/T] (dashed), (c)I_p=133[kA/T] (dotted), respectively.

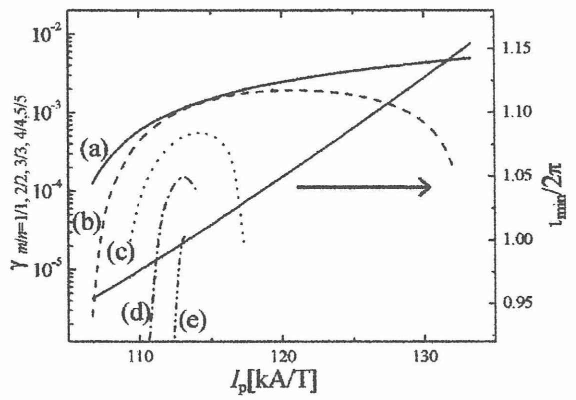

Fig. 2: Growth rate of current driven instabilities and minimum rotational transform (a) m/n=1/1 mode, (b) m/n=2/2 mode, (c) m/n=3/3 mode, (d) m/n=4/4 mode and (e) m/n=5/5 mode, respectively.

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