§6. Response of Interchange Instability to Resonant Magnetic Field by External Coils

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Externally applied resonant magnetic perturbation (RMP) is a powerful tool for the control of MHD instabilities in magnetically confined toroidal fusion plasmas. Experimental and theoretical studies have been carried out extensively in tokamaks and helical plasmas. In tokamaks, the RMP has been applied successfully for stabilization of the resistive wall mode (RWM) and control of the edge localized mode (ELM). In helical plasmas, it has been demonstrated that suppression of the magnetic fluctuations arising from edge-resonant resistive interchange modes is possible by applying RMP, and resultant improvement of confinement is observed in LHD.

Figure 1 shows the dependence on the RMP magnitude of the magnetic fluctuation amplitude associated with the m/n=1/1 mode whose resonant rational surface is located at ρ~0.9, where m (n) is the poloidal (toroidal) mode number, and ρ is the normalized minor radius. The RMP magnitude is expressed by the amplitude of the external coil current I_{RMP} normalized to the helical heliotron field B_0. The resonant m/n=1/1 mode amplitude decreases with an increase in RMP magnitude, approaching 0 at I_{RMP} of 1 kA/T. Further increase in RMP results in disappearance of the m/n=1/1 fluctuations.

Figure 2 shows the change of electron temperature profile as the RMP magnitude increases. When the RMP is applied with IRMP of 1.0 kA/T, higher electron temperature is observed inside the mode resonant surface (ι/2π=1, denoted by the dashed line). In contrast, when the RMP magnitude is larger, (IRMP=1.3 kA/T), the temperature profile becomes flat around the resonant surface, with lower temperature inside the resonant surface.

We have shown that the externally applied RMP penetrates into the resonant surface for IRM higher than 1.1 kA/T by observing the change in its phase due to the plasma. This observation is consistent with the presently observed appearance of the flat region of the temperature at IRMP of 1.3 kA/T shown in Fig.2. Thus, we have concluded that plasma performance or confinement performance can be improved with RFP at an appropriate magnitude where magnetic fluctuation is suppressed, and as a result confinement properties are improved.

As mentioned above, we have already shown that the edge localized m/n=1/1 mode can be suppressed by applying RMP. It has also been demonstrated that the effect of confinement improvement by suppressing the m/n=1/1 edge mode is ~5% (in terms of the beta value) since in the edge region the magnetic shear is high and the radial extent of the mode is small.

On the other hand, it has been predicted that the core resonant modes have larger radial extent in the lower shear region in the core. Figure 3 shows the stronger effect of the core resonant mode on the confinement improvement (in terms of beta value). This phenomenon is observed in the case with inward-shifted configuration where beta value tends to be lower than the case shown in Figs.1 and 2. As is clear in the figure, the beta value is improved by ~20% when the core resonant m/n=2/1 mode disappears. In this particular case, it has been made clear that the reason of disappearance of the mode is due to the disappearance of the corresponding m/n=2/1 mode resonant surface in the core region.

The above two examples indicates that core resonant MHD instabilities have stronger effects on the confinement improvement than edge localized modes when the mode is stabilized. We proposed experiments to examine if we can stabilize the core resonant mode by applying the RMP. Unfortunately, no machine time was assigned to our experiment. We hope some machine time would be approved for our proposal in the experimental campaign for FY 2015.

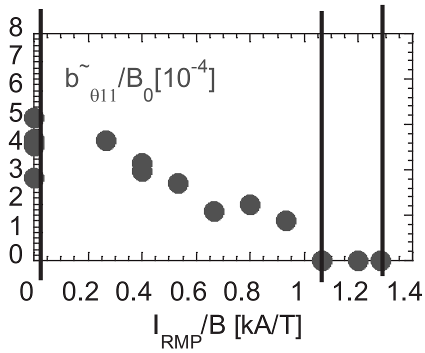

Fig.1 Dependence on RMP of the m/n=1/1 magnetic fluctuation.

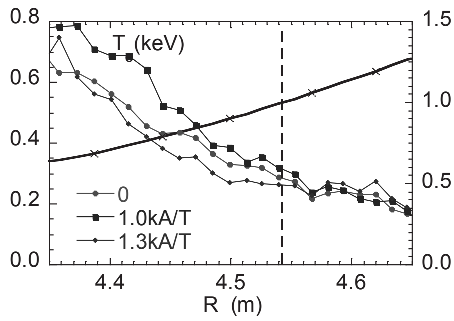

Fig.2. Change in electron temperature profile with RMP.

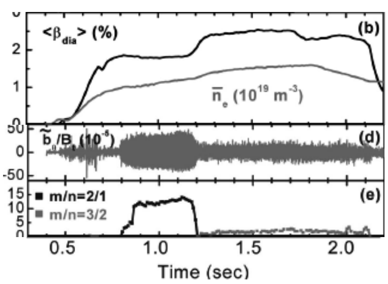

Fig.3. Change in confiinement characteristic in the absence of core resonant mode. [1]

1) S. Sakakibara et al., plasma Fusion Res. 1 (2006) 006.