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

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It is reported that the low-n fluctuation due to the resistive interchange MHD instability resonated at a peripheral rational surface in LHD high-beta discharges is localized in the radial direction and induces the degradation of the energy confinement[1]. In recent LHD experiments, the suppression method of the MHD activity is under the development by using the externally installed RMP (resonant magnetic perturbation) coils. On the study, a following primitive result was already reported; the fluctuation signals observed by the pick-up magnetic coils decreases as the static RMP coils current increases, even in the case that the pressure gradient do not change little[2]. In this study, we focus on the following aspects to make clear the suppression mechanism of the interchange instability due to the external RMP coils;

(1) How does the interchange instability interact with the RMP induced by the external coils?

(2) Is the interchange instability completely suppressed by the external RMP coils?

Figure 1 shows the dependence of (a) the magnetic fluctuation amplitude with m/n=1/1 mode (m and n are the poloidal and the toroidal mode numbers, respectively, the resonant rational surface is located at ρ~0.9, ρ; the normalized minor radius) and (b) the phase deference between the RMPs induced by the plasma and the external coils on the external RMP coil current. In Fig.1(b), "-1.0π" denotes that the RMP induced by plasma cancels that by external coils. Figure 1(b) denotes that the RMP by the external coils does not penetrate the plasmas when the normalized coil current of RMP (I_{RMP}/B_0) is below 1.05kA/T, which is consistent with the behavior of the electron temperature and density profiles, that is, any changes do not appear in the profiles. From this result, we have confirmed that the RMP by external coils can suppress the magnetic fluctuation activities without any change of the pressure profile.

Figure 2 shows the dependence of the magnetic fluctuation amplitude with m/n=1/1 mode (■) and the maximum value of the normalized fluctuation amplitude ($\tilde{\Gamma}_{SX}/\Gamma_{SX}$) of the soft-X ray emission signal in the direction of the minor radius (●) on the external RMP coil current. Here Γ_{SX} is the time averaged soft-X ray signal. It should be noted that the data in Fig.2 is for the discharges with different experimental conditions (operational magnetic field strength and amount of heating power) from that in Fig.1, then the data in Fig.1(a) is not exactly same with that in Fig.2. Figure 2 shows that the soft-X ray emission fluctuation signal also decreases as the external RMP coil current increases in addition to the magnetic probe fluctuation signals. From this result, we have confirmed that the RMP induced by the external coils can suppress the resistive interchange instability.

From the results, the RMP induced by the external coils can suppress the resistive interchange instabilities without any change of the pressure gradient, which suggests that the suppression is not induced by the change of the plasma parameters at resonant magnetic surface, but by the change of the plasma parameters at the plasma boundary.

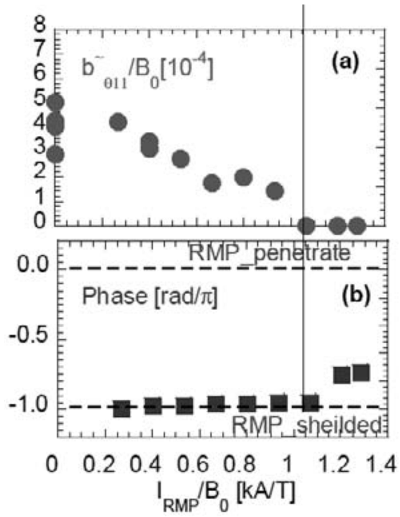

Fig. 1. Dependence of (a) the magnetic fluctuation amplitude with m/n=1/1 mode and (b) the phase deference between the RMPs induced by the plasma and the external coils on the external RMP coil current.

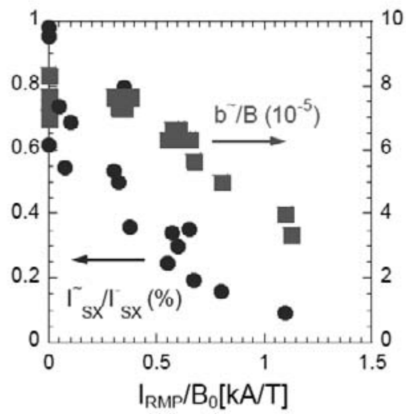

Fig. 2. Dependence of the magnetic fluctuation amplitude with m/n=1/1 mode (■) and the maximum value of the normalized fluctuation amplitude ($\tilde{\Gamma}_{SX}/\Gamma_{SX}$) of the soft-X ray emission signal in the direction of the minor radius (●) on the external RMP coil current.

1) K.Y.Watanabe et al., Phys. Plasmas 18, 056119 (2011).
2) S. Sakakibara et al., Proc. in 33th EPS, Rome, Jun. 2006 ECA Vol. 301, p- 4.113 (2006).