§36. Study of Error Field Mode in LHD

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An effect of an error field mode on the equilibrium and plasma confinement has been investigated in the Large Helical Device. Previous study shows that non-rotating m/n = 1/1mode suddenly grows when the magnetic shear decreases by reduction of plasma aspect ratio, A_p, and/or plasma current increasing the rotational transform[1)], and this mode is thought to be due to natural error field[2)]. In this study, resonant magnetic field (RMP) is externally applied in different magnetic shear configurations, in order to clarify the dependence of the threshold where the external magnetic field penetrates inside plasmas on the magnetic shear. When the A_p is changed from 6.6 to 8.3, magnetic shear, $d(\iota/2\pi)/d\rho$, on the $\iota/2\pi = 1$ resonance decreases from 2 to 1. The experiments were done in the configurations with A_p of 6.6, 7.1, 7.7 and 8.3. The electron density, toroidal field and heating power were almost the same in any configuration. Two co- and a counter neutral beam injections were applied to produce the target plasma, and plasma was maintained by the balanced injection so as to decrease the plasma current. The positive (negative) RMP current produces m/n = 1/1 magnetic island where the toroidal angle of O-point is 54° (-126°). Figure 1 shows the typical RMP discharges in the A_p = 6.6 and 8.3 configurations. The normalized RMP current, I_{RMP}/B_t, started to increase at the beginning of discharges, and reached 0.76 kA/T in 2 sec as shown in Fig.1(a). In the case of A_p = 6.6 (solid line), RMP was shielded till 2.5 s and abruptly penetrated when the I_{RMP}/B_t exceeded a certain value. Then averaged beta started to decrease (Fig.1(b)). The time evolution of the magnetic island estimated by magnetic flux loops indicates that magnetic field cancelling the RMP appeared till 2.5 s (Fig.1(c),(d)). The island width is larger than that predicted by calculation. On the other hand, in the case of A_p = 8.3 (dotted line), the magnetic island appeared before RMP was applied. The island width increased and decreased till 2.2 s, which is thought to be due to turned-off of a neutral beam. It gradually increased again with increasing I_{RMP}/B_t.

The experimental results are summarized in Fig.2. The figure shows that the “mode penetration” easily occur when the A_p (magnetic shear) increases (decreases). The error bar was estimated through other static RMP experiments, which is consistent with the ramp-up case. The absolute value of two thresholds is quite different, and the average value is about 0.12 kA/T in any A_p configuration. This value seems to correspond to that required for cancellation of the natural error field, and the island size, w_{err}, is about 0.14 m. The position of natural magnetic island is consistent with previous flux mapping experiment in vacuum, whereas the island size is slightly different. One of the reasons is thought to be due to finite-beta effects.

The experiments clarify the effect of the magnetic shear on the mode penetration, whereas it is predicted that plasma flow significantly affect the threshold of the penetration[3)]. The effects of plasma parameters and the magnetic configuration on the penetration will quantitatively estimated through the experimental database in near future.

1) S.Sakakibara et al., Fusion Sci. Technol. 50 (2006) 177.
2) Morisaki et al., Fusion Sci. Technol. 58 (2010) 465.
3) T.C. Hender et al., Nucl. Fusion 47 (2007) S128.

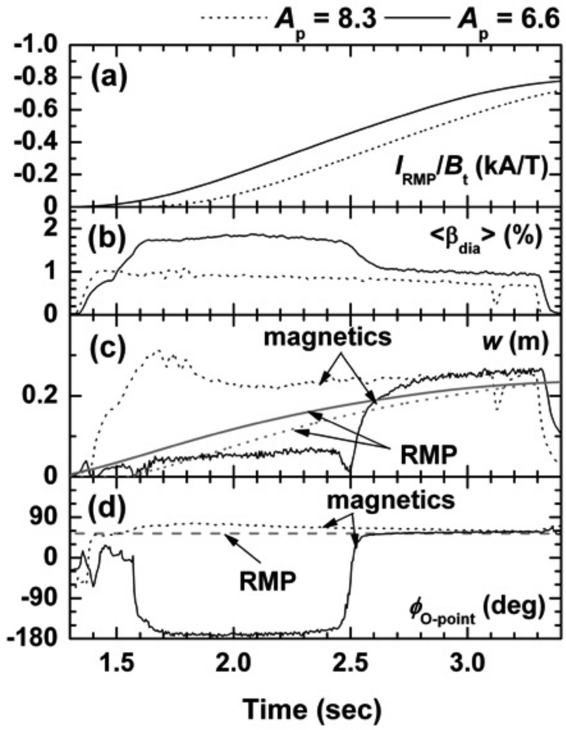

Fig.1 Typical RMP ramp-up discharges in A_p = 8.3 and 6.6 configurations.

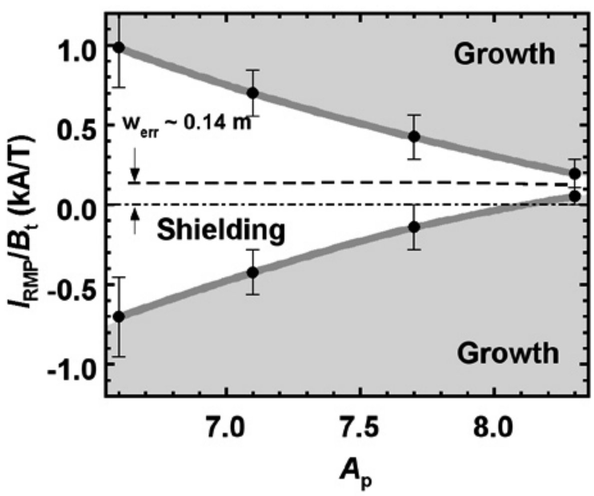

Fig.2 Threshold RMP of magnetic field shielding in different A_p configurations.