§18. Effects of Plasma Flows on Penetration Threshold of External RMP Field in LHD

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The RMP (Resonant Magnetic Perturbation) is applied as the effective control knob to improve the confinement performance in the torus plasmas. Though the RMP was considered to always induce the island structure in the plasmas, it is sometimes shielded. The phenomena are observed both in tokamaks and helicals including the LHD. To understand the mechanism of the penetration and the shielding of external RMP fields, the research on the penetration threshold dependence of the m/n=1/1 RMP in the various LHD plasmas with the wide range of beta and collisionality is progressed[1, 2].

The experiments are done so that the RMP coil's current increases during the discharges with the almost same density and temperature. There the change of the perturbed field produced by the plasma and the velocity of the poloidal flow and toroidal flow by CXRS are measured. Plasma is maintained by the balanced injected NB. In table 1, the dependence of the threshold on the collisionality for the various LHD configurations. Here A_p is the plasma aspect ratio. We obtain the following results from the table; the penetration threshold increases as the collisionality in the low aspect plasmas, but the threshold decreases as the collisionality in the high aspect plasmas. The configuration dependence is a quite unique characteristics of the LHD plasmas unlike tokamaks. It should be noted that the experiments are done in the collisionality regimes between the so-called 1/ν and the plateau regimes.

As a provable candidate of the determination mechanism of the penetration threshold, the "torque balance" model is proposed in tokamaks and helical plasmas [3, 4]. In the models, the external RMP field penetrate the plasma (at the resonant rational surface) when the electromagnetic torque induced by RMP overcomes a viscos torque, and the plasma rotation stops. Before the penetration of the external RMP, the plasma rotation is driven by the viscos torque. Then to confirm the validity of the models, the relation between the penetration threshold and the plasma rotation speed would be a key index.

		A_p=7.1 (low-shear)	A_p=6.7	A_p=5.7 (high-shear)
threshold	β=1~1.2% (1T)	$\nu_{*b}^{-0.23}$	$\nu_{*b}^{-0.05}$	
	β=0.8~1% (1.38T)	$\nu_{*b}^{-0.18}$		$\nu_{*b}^{+0.10}$

Table 1 The threshold as the function of the collisionality in the various configurations with R_{ax}^{V}=3.6m.

Figure 1 shows the dependence of (a) the penetration threshold and the (b) the toroidal rotation speed on the collisionality for the A_p=5.7 and 7.1 plasmas with β=0.8~1%. Toroidal rotation frequencies are much smaller than poloidal ones. Amplitude of toroidal rotation frequencies are almost same independent of A_p, which suggests that the toroidal flow would not have strong impact on the RMP shield. Figure 2 shows the dependence of the penetration threshold on the poloidal rotation speed for the A_p=5.7 and 7.1 plasmas with β=0.8~1% and 1~1.2%. In lower poloidal rotation, the plasmas shield the external RMP more easily. Penetration thresholds increase as poloidal rotation frequencies increase in spite of large scatters in the poloidal flow data. The above results suggests that in the case of the balanced injected NB, the poloidal viscosity would be a key parameter on the determination mechanism of the penetration threshold of the external RMP field, which is consistent of some theoretical proposals in the helical plasmas[4, 5]. However, the dependence of the penetration threshold on the collisionality and configurations is not still resolved. It is a future subject.

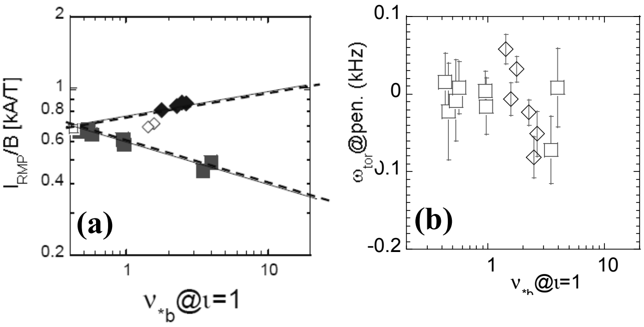

Fig. 1 (a) Penetration threshold and (b) toroidal rotation speed as the function of the collisionality. □ and ■ are for A_p=7.1, and ◆ and ◇ are for 5.7.

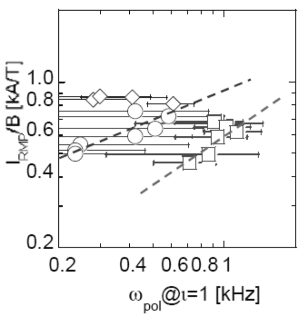

Fig. 2 Penetration threshold as the function of poloidal rotation speed. ◇ and □ are for β=0.8~1%, and ○ is for 1~1.2%. ○ and □ are for A_p=7.1, and ◇ is for 5.7.

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