§24. Plasma Response of Resonant Magnetic Perturbation 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 LHD. The understanding of the mechanism and the knowledge of the penetration condition are an important issue for the application of RMP to suppress the MHD activities and so on. The most remarkable result on early RMP works in LHD is the observation of the clear dependence of the RMP penetration threshold on the magnetic configuration (magnetic axis location and plasma aspect ratio) [1,2]. The property has not been reported on the tokamaks. The probable explanation is that the damping of the poloidal flow (determined by the competition between the RMP driven electro-magnetic torque and the neoclassical viscosity), which is a key parameter of the RMP shielding, has a configuration dependence. The explanation is consistent with the magnetic axis location dependence[2], but the validity for the aspect ratio has not been clarified.

Recently, the research on the threshold dependence of the m/n=1/1 RMP on the density and the collisionality for the various configuration in LHD is progressed. 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 prodcued by the plasma and the velocity of the the poloidal flow and toroidal flow by CXRS are mesaured. Figure 1 shows the threshold as the function of the density (a) and the collisionality (b) in the configuration with A_p=7.1 (so-called relatively 'low-magnetic shear' config.), $R_{ax}{}^V$=3.6m and B_0=1T. Here the closed symbols denote the data with 1~1.2% of the beta value. The threshold decreases as the density increases and the collisionality increases. Here it should be noted that in tokamaks' researches the the threshold increases with the density, and it does not depend on the temperature explicitly, as shown in the following[3].

$$B_{\mathrm{pen}}/B_{\mathrm{t}} \propto n^{\alpha_n} B_{\mathrm{t}}^{\alpha_B} q_{95}^{\alpha_q} R^{\alpha_R} \quad , (\alpha_n \sim 1)$$

The LHD's dependence on the density is quite different from that in tokamaks as mentioned in the above. In table 1, the dependence of the threshold on the density (a) and the collisionality (b) for the various LHD configurations. 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. Here it should be noted that the different toroidal flow behavior during the RMP penetration is observed for different aspect ratio; the change of the toroidal flow is clear in the high aspect plasmas, but it is not clear in the low aspect plasmas. The behavior would be related with the resonant surface location. The surface of the higher aspect plasma is closer to the core region, and the toroidal flow can be larger at the surface is closer to the core in LHD. The investigation on the above RMP penetration threshold dependence would lead to the understanding of the RMP shielding and perturbation mechanism on the tokamak plasmas, where the toroidal flow is considered an important key parameter on the plasma response on the RMP. And the understanding of the RMP shielding mechanism is also the important key issue to investigate the stabilization mechanism of the interchange mode without the RMP penetration in LHD[4].

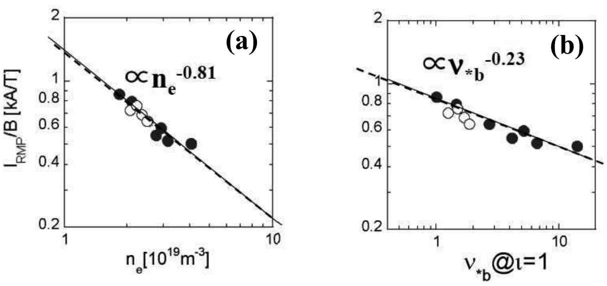

Fig. 1 The threshold as the function of the density (a) and the collisionality (b) in the configuration with A_p=7.1, $R_{ax}{}^V$=3.6m and B_0=1T.

(a)		A_p=7.1 (low-shear)	A_p=6.7	A_p=5.7 (high-shear)
threshold	1T	$n_e^{-0.81}$	$n_e^{-0.05}$	
	1.375T	$n_e^{-0.53}$		$n_e^{+0.42}$

(b)		A_p=7.1 (low-shear)	A_p=6.7	A_p=5.7 (high-shear)
threshold	1T	$\nu_{*b}^{-0.23}$	$\nu_{*b}^{-0.05}$	
	1.375T	$\nu_{*b}^{-0.18}$		$\nu_{*b}^{+0.10}$

Table 1 The threshold as the function of the density (a) and the collisionality (b) in the various config. with $R_{ax}{}^V$=3.6m.

[1] S.Sakakibara, et al., Nucl. Fusion. 53 (2013) 043010.
[2] Y.Narushima, et al., 2014 IAEA conference EX/P6-35.
[3] R. Buttery, et al., Nucl. Fusion. 39 (1999) 1827.
[4] K.Y.Watanabe et al., 24th International Toki Conference, Nov. 2014, Toki(Japan), P4 - 6.