§11. Study of Healing Boundary of Magnetic Islands in the LHD

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Magnetic islands present in the vacuum configuration of LHD plasmas can be spontaneously healed. In the previous LHD experiment [1], the magnetic island states (growth or healing) can be clearly divided into two regions in the β and collisionality space. The island growth region (where is filled by closed circles) becomes wider with increase in RMP coil current, as shown in Fig.1. These data were acquired from the discharges transiting from growth to healing. While β and collisionality could correlate with island physics through Pfirsch-Schlüter (PS) and bootstrap (BS) current effects, efforts to understand these results via these mechanisms demonstrated that other ingredients, unknown at that time, were necessary to explain island behavior. The understanding of the decision mechanism of that boundary dividing the island states had been left as a problem to solve. A recent study has found that the dynamics of the magnetic island is affected by the poloidal plasma rotation [2], which shows the experimental fact that the poloidal flow changes prior to the transition of magnetic island from growing to healing. Subsequently, experimental and theoretical works suggested that the properties of the plasma flow [3-8] have a powerful influence on the magnetic island behavior. Associated with the transition from a locked (growth) island to a healed state is a large change in the rotation profile in the vicinity of the rational surface. Focusing on the poloidal flow, theories based on the torque balance relations have been proposed to describe transitions between two asymptotic states [4-8]. Figure 2 shows the relationship between the theoretically derived critical beta β_{crit} [5] and experimentally obtained beta β_{exp}, which is consistent with empirically derived scaling. Comparisons between the theory and observations on LHD show favorable agreement.

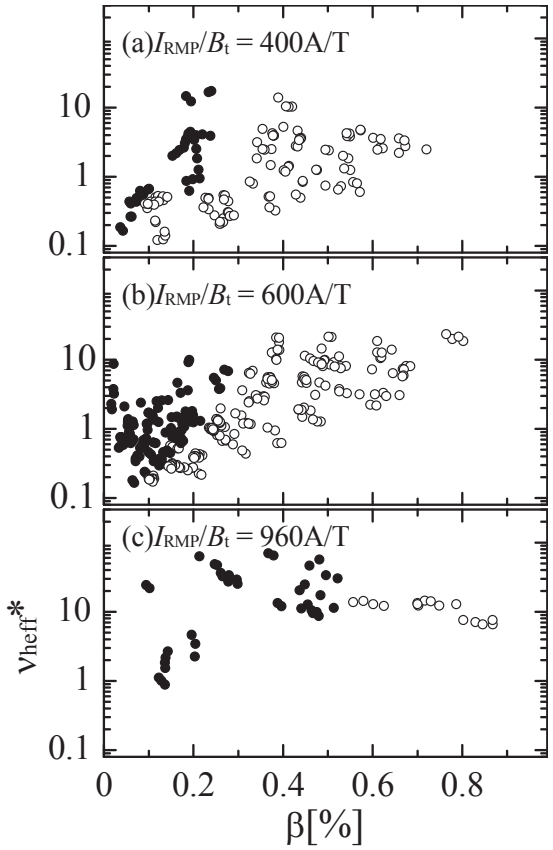

Fig. 1 Plasma beta and collisionality space of Island growth and healing transition. Closed and open symbols indicate island growth and healing respectively. Normalized RMP coil current I_{RMP}/B_t are 400A/T (a), 600A/T (b), and 960A/T (c), respectively.

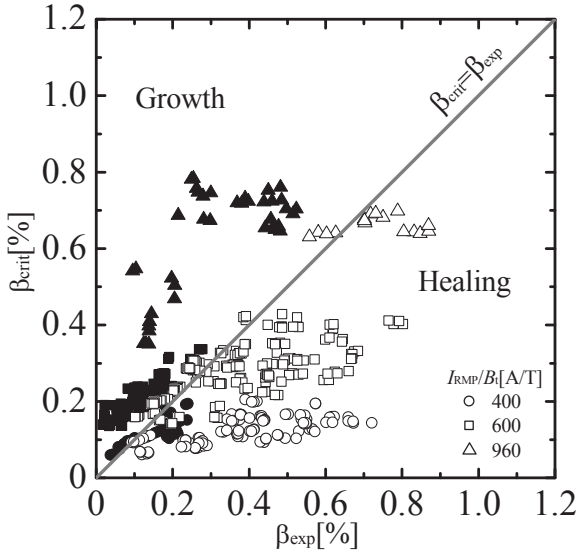

Fig. 2 Island healing transition boundary. Closed and open symbols indicate island growth and healing respectively. Normalized RMP coil current I_{RMP}/B_t are 400A/T (circle), 600A/T (square), and 960A/T (triangle), respectively.

[1] Y. Narushima, et al., Nuclear Fusion 48 (2008) 075010
[2] Y. Narushima, et al., 2011 Nuclear Fusion 51 083030
[3] Y. Narushima, et al., *"Experimental Observation of Response to Resonant Magnetic Perturbation and Its Hysteresis in LHD"* accepted in Nuclear Fusion
[4] S. Nishimura, et al., 2015 Physics of Plasmas 22, 022521
[5] C. C. Hegna 2012 Physics of Plasmas 19 056101
[6] S. Nishimura, et al., 2012 Physics of Plasmas 19 122510
[7] C. C. Hegna 2011 Nuclear Fusion 51 113017
[8] S. Nishimura, et al., 2010 Plasma Fusion Res 5 040