§44. Effect of Poloidal Flow on Magnetic Island Dynamics

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Dynamics of magnetic island in LHD plasmas are studied. Previous experiments have shown that a magnetic island behavior depends on β and ν in the quasi-steady state [1-3]. To clarify the dynamic behavior of the magnetic island intersecting the boundary between growth and healing, the heating power of the neutral beam (NB) is changed in a single discharge. The poloidal flow starts increasing before the magnetic island transits from growth to healing, and vice versa. The profiles of electron temperature (T_e) measured near the O-point of the island are shown in Fig.1 (b-d) in which the seed island with poloidal/toroidal Fourier mode numbers of m/n = 1/1 is embedded by external perturbation coils. The resonant surface of $\iota/2\pi = 1$ lies at r_{eff} = 0.55m. The local flattening of the T_e profile indicates the existence of the magnetic island at t = 2.333s and 2.533s as shown by the horizontal lines in Fig.1 (a)(b). After that, the island disappears at t = 2.933s (Fig.1 (c)). The profiles of poloidal flow ($\omega_{E\times B}$) measured near the X-point of the island are also shown in Fig.1 (a-c). The positive (negative) value of $\omega_{E\times B}$ indicates the ion (electron)-diamagnetic direction. The minimal value of $\omega_{E\times B}$ lying at r_{eff} = 0.6m reduces with time and its profile becomes wide during the magnetic island healing. The time evolution of NB power, resonant field amplitude ($\Delta\Phi^r_{m=1}/B_t$), difference of the poloidal angle of X-point from the seed island ($\Delta\theta_{m=1}$) and $\omega_{E\times B}$ at r_{eff} = 0.6m are shown in Fig.1 (d-g). The poloidal flow is measured from t = 2.34s to 2.94s at intervals of 0.1s. The sequence of magnetic island dynamics is as follows: the $|\omega_{E\times B}|$ at r_{eff} = 0.6m (Fig.1(g)) increases from t = 2.34s to 2.54s prior to the island being healed; $\Delta\Phi^r_{m=1}/B_t$ starts decreasing at t = 2.62s which means that the island width decreases (Fig.1 (e)). At that time, the $|\omega_{E\times B}|$ at r_{eff} = 0.6m further increases from 6 to 13krad/s. The $\Delta\theta_{m=1}$ starts shifting (rotating) to the electron-diamagnetic direction at t = 2.67s (Fig.1 (f)), which implies that the current sheet in the plasma is modified by the poloidal flow. Finally, the magnetic island is healed. Figure 2 shows that the island width is reduced in some cases below $\omega_{E\times B} \sim$ -5krad/s, and that there exists a threshold of $\omega_{E\times B}$ between -5 and -8krad/s for healing. When the magnetic island undergoes the transition from healing to growth, the $|\omega_{E\times B}|$ starts decreasing before the transition, and the threshold of $\omega_{E\times B}$ is in the range from -5 to -8krad/s.

The poloidal flow in the electron-diamagnetic direction outside the rational surface increases prior to the transition of the magnetic island from growth to healing. The temporal increment of the poloidal flow is followed by the transition (growth to healing) of the magnetic island regardless of the flow direction. These experimental observations clarify the fact that a significant poloidal flow affects the magnetic island dynamics. Due to the increase of the poloidal flow, the viscous drag force overcomes the magnetic torque between the externally imposed field and the current sheet. As a result, the current sheet is shifted (rotated) and heals the magnetic island.

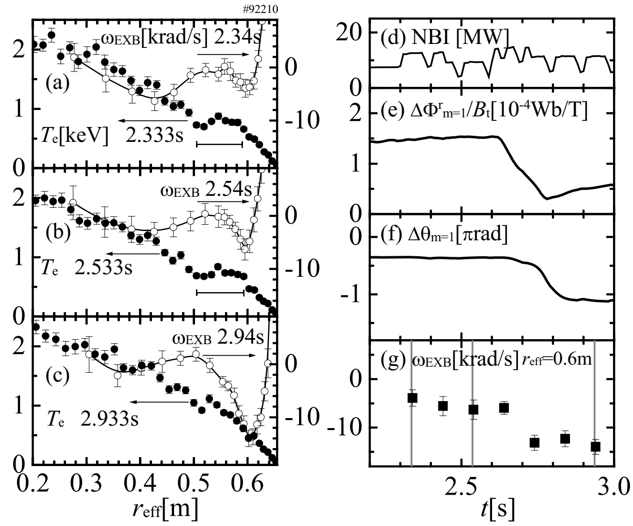

Fig.1 (a-c) Radial profile of T_e (closed) and $\omega_{E\times B}$ flow (open). (d-g) Time evolution of NBI, $\Delta\Phi^r_{m=1}/B_t$, $\Delta\theta_{m=1}$ and $\omega_{E\times B}$. The island (local flattening at $r_{eff} \sim$ 0.55m) transits from growth to healing. The $|\omega_{E\times B}|$ increases with time prior to the island being healed.

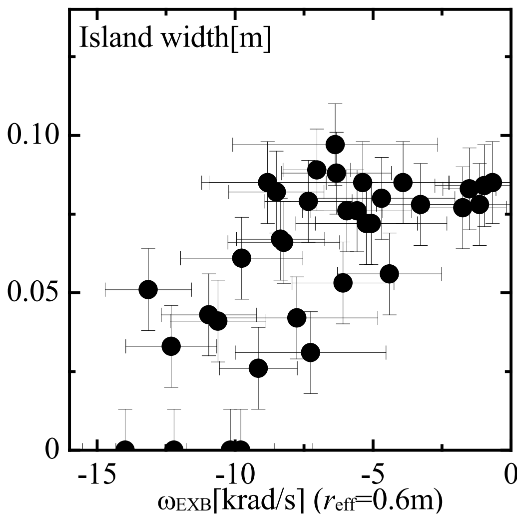

Fig.2 Relationship between $\omega_{E\times B}$ and island width. Island width decreases when $\omega_{E\times B}$ falls below -5krad/s.

1) Y. Narushima, et al., Nuclear Fusion 48 (2008) 075010
2) Y. Narushima, et al., Fusion Science & Technology (To be published)
3) Y. Narushima, et al., Contributions to Plasma Physics (To be published)