§45. Study of Effect of Plasma Shape and MHD Equilibrium Limit

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Plasma shape control is a major knob to investigate confinement as well as MHD characteristics of magnetically confined plasmas. In particular, plasma elongation has been widely explored in many experiments and theoretical investigations. For example, optimization in the line of W7-AS and W7-X owes much to reduction of Pfrisch-Schlueter currents due to elongation. It is also widely recognized that plasma elongation affects energy confinement in tokamaks, which can be seen in the ITER H-mode scaling.

In heliotron plasmas, when the shape of flux surfaces is elongated vertically (horizontally), following characteristic are predicted by numerical and analytical analyses based on the stellarators expansions: (i) the rotational transform on the axis is decreased, (ii) the Pfirsch-Schluter current is suppressed (enhanced), (iii) the Shafranov shift toward the outside of the torus is small (large). Since the Shafranov shift is enhanced by horizontal elongation, equilibrium β limit is lowered in oblate configuration. In general, the equilibrium β limit is defined by the Shafranov shift as large as a half the minor radius, when the deformation of magnetic flux surface is thought not to be tolerable. However, this is not physically reasonable definition. In the tokamak case, the separatrix is generated inboard side due to enhanced Pfrish-Schlueter currents. Oblate configuration provides the experimental evidence what happens by a large Shafranov shift and can mitigate the approach to the question what the equilibrium β limit is.

In order to consider equilibrium β limit, we study an oblate configuration (BQ=200%). This configuration is elongated by the external quadrupole field. If the horizontal elongation is superimposed strongly, vacuum magnetic axes were split. Those configurations had already studied in the theoretical and experimental analyses[1)2)]. In this study, since we are interesting the marginal region to equilibrium β limit, we adapt this configuration. Figure 1 shows time evolutions of the stored energy at a shot (#77964). The input power of NBI #1, #2 and #3 is also showed as the reference. The stored energy is sustained for t=1~2[s]. Figure 2 shows pixel maps of SXCCD tomography along the tangential view line. Pixel maps changed horizontally at later time slice. This suggests the shape of flux surfaces elongated horizontally. However, appearing of the separatrix is still unclear. In order to confirm appearing of the separatrix, 3D MHD equilibrium calculation without the assumption of nested flux surfaces is necessary. This is a future subject.

1) Suzuki, Y. et al. : Nucl. Fusion **46**, (2006) 123
2) Yamada, H. et al. : Fusion Sci. Technol **51**, (2007) 138

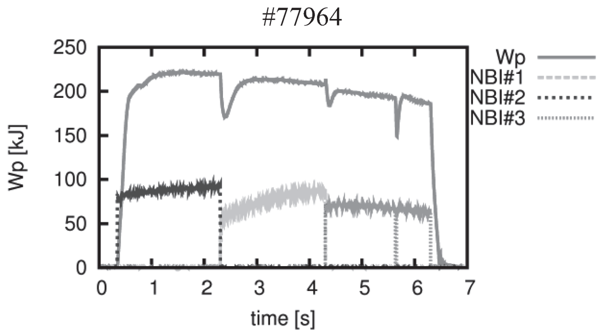

Fig. 1. Time evolutions of profiles of the stored energy and input power of NBI#1, #2 and #3.

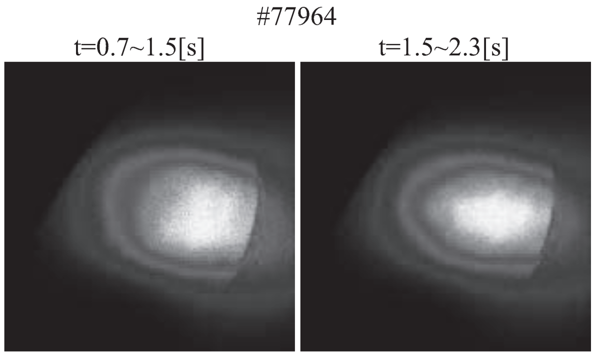

Fig. 2. Pixel maps of SXCCD Tomography are shown for different time slices at t=0.7~1.5[s] and 1.5~2.3[s]. The shape of pixel maps elongates horizontally.