§29. Effect of Separatrix Geometry on Transport and MHD

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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. On the other hand, the role of separatrix has been attracting interest in both a fundamental issue of a dynamical system with cross of stable and unstable manifolds and applied issues for performance of magnetic confinement. Many reports can be referred to the latter issues, which are related to dynamics of magnetic islands and its effect on transport, equilibrium β limit and a function of divertor. 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.

Figure 1 shows the electron temperature profile in the experiment and the pressure profile calculated by HINT in the case of κ of 0.5 [1]. Both profiles are plotted along the major radius. As shown in Fig. 1 (a), the Shafranov shift beyond a half the minor radius is already observed in low β (0.3%). Along with the increase in β, inflection of temperature gradient appears inboard side of the peak. This evolution of profile is well reconstructed by the HINT calculation. The calculation of HINT indicates that large Shafranov shift occurs even in low β since the separatrix geometry already exists in the vacuum condition and the rotational transform is close to zero. With increase in β, the outer petal evolves while the inner petal degenerates. The outer region of the petal, namely the outside of the internal separatrix becomes stochastic and loses confinement capability. This trend is pronounced in the inboard side of the outer petal in the physical space. While large pressure gradient is maintained in the outer petal (outer separatrix domain), the pressure gradient declines in the outside of this region. This physical picture seems to be consistent with the experimental observation. The reason why the experimental observation in the inboard side is somewhat mitigated from the prediction by HINT may be healing of ergodization due to unresolved dynamics of the plasma or tolerable parallel heat transport. Although the direct measurement of the change of magnetic geometry is not available, circumstantial evidence supports the validity of the calculation by HINT. Subsequently the picture of equilibrium β limit can described based on results from the calculation by HINT [2].

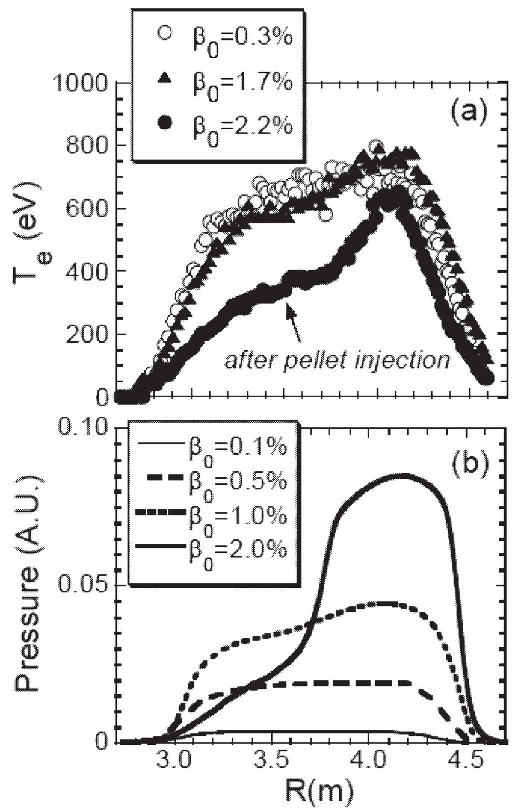

Fig.1 Profile evolution in the configuration with κ of 0.5. (a) Electron temperature in NBI heated plasmas measured by Thomson scattering, (b) Pressure profile calculated by HINT.

[1] Y. Suzuki, *et al*. Nucl. Fusion **46** (2006) 123
[2] H.Yamada, *et al*. Fusion Sci. Technol. (accepted)