§18. Edge Plasma Pressure Gradients in NBI Heated Plasmas with Electron Density Clamping

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In helical plasmas the clamping of electron density is often observed during intense ECH. The role of energetic electrons trapped in helical field ripples is discussed to be a possible mechanism. In LHD, the density clamping is sometimes observed during intense tangential neutral beam injection, even if appreciable amount of fuel gas is continuously injected. This phenomenon may be explained by the reduction of particle recycling (or reduced particle fueling efficiency) due to high edge electron temperature. However, the density clamping is more obvious in the low toroidal field (Bt) cases than high Bt cases where the higher edge Te is achieved. Here, we discuss the correlation between the density clamping and the magnitude of the edge pressure gradient. In the edge region in LHD, the resistive interchange modes with low to medium poloidal mode number m will usually be unstable because of magnetic hill region there. Moreover, drift wave type instabilities in a finite beta plasma will be also important candidates to impede the rise in edge pressure gradient. Recently, coherent magnetic and soft X-ray fluctuations with m=3/n=3 and m=2/n=2 are detected in the plasma edge around the 1/q=1 rational surface[1]. They are thought to be low m resisitive interchange instabilities. Here, we study edge pressure gradient in two types of NBI heated plasmas, that is, (1) high heating power case at high field Bt=2.75 T, and (2) lower heating power case at low field Bt=1.5 T.

In the case (1) (Bt=2.75 T), the NBI power was stepped down from 3.5 MW balanced injection to 1.9 MW counter injection during the constant gas puffing. The density rise suppressed in the high power phase of 3.5 MW recovers in the phase when the power is stepped down to 1.9 MW. The edge electron pressure gradient in the high power phase stays at $(-d\beta e/dr)_{max}$ ~ 1.4 %/m. In the low power phase the edge gradient is ~ 0.9 %/m and the electron density rises in time.

Typical time evolutions of line integrated electron density at various chord lines and stored energy in the case (2) are shown in Fig.1, where co-NBI power is 1.3 MW and counter NBI 0.9 MW at Bt=1.5 T. As seen from Fig.1, clear density clamping takes place during the higher power phase. Moreover, the electron density

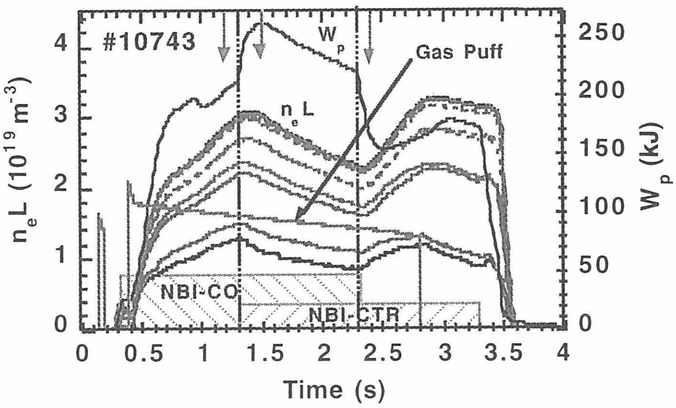

Fig.1 time evolutions of line integrated electron densities at various chird lines of the interferometer, stored plasma energy and gas puff.

decrease from t=1.3 s starts near the edge and propagates towards the plasma core region. The recover of the density clamping starts from t=2.3 s near the edge to the core region. When the edge pressure gradient reaches a certain threshold ($(-d\beta e/dr)_{max}$ ~ 1.6 %/m), the electron density starts to decrease. As far as the edge pressure gradient stays the above threshold, the desity clamping persists. The radial profiles of the edge electron pressure calculated from experimentally obtained electron temperature and density are shown in Fig.2 for three time thrices: just before the density clamping(t=1.2 s), during the clamping(t=1.5 s) and the recovery phase (t=2.4 s). This suggests that when the edge pressure gradient reaches a certain threshold by plasma heating, the rise of electron density might be impeded. The limiting mechanisms of edge pressure gradients are being studied.

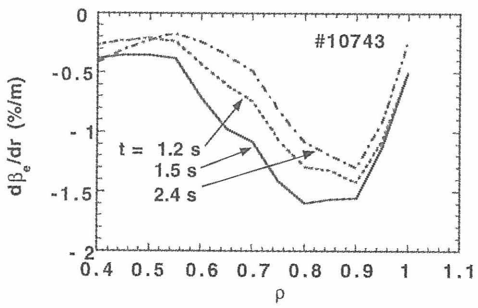

Fig.2 *Radial profiles of electron pressure gradient before, during and after density clamping.*

[1] M. Takechi et al., to be published in J. Plasma Fusion Res SERIES (2000).