§9. A Change of the Edge Density Profile in the ETB Plasmas

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From the poloidal rotation of C^{6+} at the edge pedestal region of $\Delta r/a \approx 0.1$ and $\Delta T_i \approx 100$eV in the ETB plasmas, it was suggested that the edge radial electric field ($E_r \approx -10$kV/m) would be determined by the proton pressure ($p_i \equiv T_i n_i$) gradient following a neoclassical prediction [1]. Since it is difficult to measure directly the proton density (n_i) profile, we shall consider this problem by using the electron density (n_e) profile with an assumption of $n_e \cong n_i$ in this region. The lithium beam probe (LiBP) method [2] is appropriate to investigate detailed structures of this density profile in this low temperature region where the Thomson scattering method is not effective.

Figure 1 shows time traces of plasma global parameters showing the spontaneous transition to the state with the ETB. The two neutral beams (40keV and 30keV, 800 kW for each) are injected into a low-density hydrogen plasma created by 200kW of electron cyclotron heating (ECH) at 53GHz. The magnetic configuration used in this example has a vacuum magnetic axis position of R_{ax}=0.92m and a quadrapole magnetic field of B_q=0. The magnetic field strength is B=0.95T at the magnetic axis. The line averaged electron density is controlled by gas puffing to keep a slow raise up to $4\times10^{13}\text{cm}^{-3}$. At t=80ms, a spontaneous low-confinement(L)/high-confinement(H) transition appears in the plasma edge region, which is shown by the drop of Hα intensity. The edge density starts to increase making a broader profile after the transition. The electron and ion temperatures are kept almost constant before and after the transition [1]. Therefore the diamagnetic plasma energy increases as well by 50% due to the increase of the density. Since the electron density and the ion temperature profiles in the core region in the ETB phase are rather flat ($\partial T_i/\partial r \cong$ 200eV/0.2m), ion pressure also has only a small radial gradient $\partial p_i/\partial r$ in the core region and has a localized large radial gradient at the edge region. In relation with the neoclassical prediction, we have to investigate the role of edge density in $(1/n_i)\partial p_i/\partial r = T_i\partial(\ln n_i)/\partial r + \partial T_i/\partial r$. Since it was already confirmed that T_i and $T_i/\partial r$ do not change clearly at the transition even at the edge [1], a change of $\partial(\ln n_i)/\partial r$ is expected. Figure 2 is the measurement result of LiBP. In many edge plasma parameter measurements in the ETB plasmas in CHS [4], the increase of the core density in r/a<1 often attracts much attention. In viewpoint of the edge E_r at $r/a \approx 1$, however, it is a "shift" to outward by $\Delta r/a \approx 1$ of the density profile rather than the "increase". It also should be noted that a fact that the edge temperatures (T_e, T_i) did not change at the transition means that the magnetic flux surface at this edge region scarcely moved by finite beta effects.

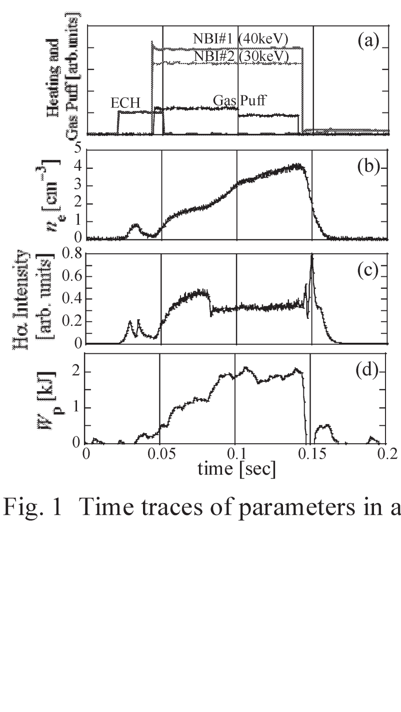

Fig. 1 Time traces of parameters in an ETB discharge.

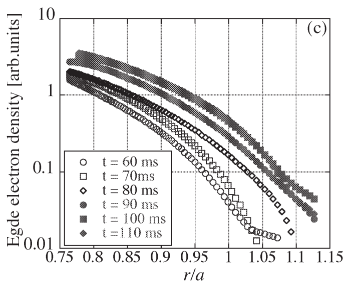

Fig.2 The edge electron density. A width of $\Delta r/a$=0.1 corresponds to that of $\Delta R \cong 2.5$cm at the equatorial plane Z=0 where the edge poloidal rotation [1] was observed.

Although the increase of the edge E_r in the low ion temperature region with T_i<100eV may be important in understanding the transition mechanism as mentioned in Ref.[1], the non-linearity of the neoclassical viscosity is only one of many hypotheses [3]. Another important observation in the ETB plasma in CHS was that the E_r shear region shifts to outward by $\Delta r/a \approx 0.1$ [1] without increasing the shear in the core region of r/a<1. This was a contrastive characteristic compared with the growth of the E_r shear in the N-ITB plasmas in CHS [5] and H-mode plasmas in tokamaks [3]. In a present study using the LiBP measurement, it was confirmed that this "shift" seems to be consistent with the change or the edge proton pressure (p_i) profile [6]. Therefore it is not a surprising fact that the turbulence and/or fluctuations in the core region r/a<1[4] are not suppressed always after the transition in spite of the improved total confinement after the transition.

Reference

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