§5. Comparisons of Density Profiles in JT-60U Tokamak and LHD Helical Plasmas

Takenaga, H., Oyama, N. (JAEA), Muraoka, K. (Chubu Univ.), Tanaka, K.

It is important for prediction of fusion performance in a fusion reactor to understand mechanisms for determining density profiles systematically in toroidal plasmas. Dependence of density profile peakedness was investigated in JT-60U tokamak and LHD helical plasmas. In ELMy H-mode plasmas on JT-60U, it was found that a density peaking factor increases with decreasing collisionality.[1)] Dependence of the density peaking factor on the effective collisionality, which provides an estimate of the growth rate of drift wave instabilities, was consistent with the interpretation that anomalous inward pinch driven by turbulent transport significantly affects the density peaking. In LHD plasmas, it was found that the density peaking factor decreases with decreasing electron-ion collision frequencies normalized by the collisionality for an upper boundary of the 1/ν region for the magnetic axes of R_{ax}=3.6, 3.75 and 3.9 m. Neoclassical outward convection velocity enhanced by helical ripples largely affected the density profile in LHD plasmas, although anomalous transport was dominant in a diffusion term.

In order to investigate characteristics of turbulences during the density profile change, density fluctuations were measured in both JT-60U and LHD.[2)] In JT-60U, density fluctuations were measured using an O-mode reflectometer employing two close frequencies (one is fixed and the other is scanned) for the cross correlation measurement of the reflected power. In LHD, density fluctuations were measured using two-dimensional phase contrast imaging.

Figure 1 shows dependence of density gradient scale length (L_n) on the radial correlation of density fluctuations in JT-60U ELMy H-mode plasmas. Here, the radial correlation was estimated as the coherence at the 20 mm radial separation of cut off layer in the frequency range from -200 to -100 kHz. In this frequency range, the highest coherence was observed. It can be seen from this figure that L_n decreases with increase in the radial correlation. Note that no systematic trend was observed between the radial correlation and the temperature gradient scale length. The radial correlation length can be a step size of diffusion. Therefore, Fig. 1 suggests that diffusion is larger for smaller L_n (more peaked profile). This result indicates that the density profile peaking is induced due to increase in anomalous inward pinch, but not due to decrease in anomalous diffusion. This is contrary to the mechanisms of density internal transport barrier formation, where the radial correlation becomes smaller and consequently anomalous diffusion is reduced.

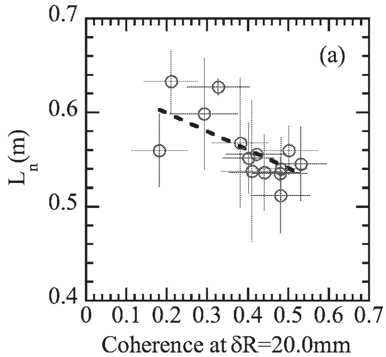

Fig. 1 Dependence of density gradient scale length (L_n) on radial correlation in JT-60U ELMy H-mode plasmas.

In LHD plasmas at R_{ax}=3.6 m, the density profiles changed from a peaked one to a hollow one by increasing the heating power (P_{NB}) from 1 to 6 MW, as shown in Fig. 2. The fluctuation power was larger for higher P_{NB} case (lower collisionality case). According to quasi-linear gyrokinetic theory, diffusion coefficients are proportional to fluctuation power. Therefore, the increase in fluctuation power observed can induce an increase of diffusion. On the other hand, neoclassical outward convection velocity increased for the high P_{NB} case. Both neoclassical and anomalous processes play roles in the change of the core density profile in LHD at R_{ax}=3.6 m. Turbulences enhanced diffusion in lower collisionality regime similar as in JT-60U. On the other hand, turbulences have only small contribution to a convection term.

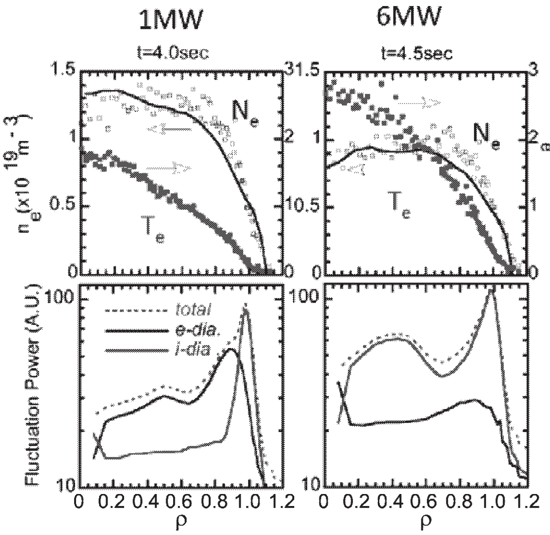

Fig. 2 Density and temperature profiles (upper) and fluctuation power in LHD plasmas at R_{ax}=3.6 m with P_{NB}=1 MW (left) and 6 MW (right).

1) H. Takenaga, K. Tanaka, K. Muraoka et al., Nucl. Fusion **48** (2008) 075004.

2) K. Tanaka, H. Takenaga, K. Muraoka et al., 22nd IAEA Fusion Energy Conference, EX/P5-6