§12. Comparison of Confinement Degradation in High Density and Particle Transport between Tokamak and Helical Devices

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A comparative study between tokamak and helical plasmas is beneficial for understanding both common physics in toroidal system and unique physics depending on each magnetic configuration. In the past two FYs, confinement degradation at high density observed in JT-60U was compared with that in LHD. In the LHD plasmas, the confinement degradation at high density was also observed at R_{ax}=3.6 m as in JT-60U ELMy H-mode plasmas. At R_{ax}=3.75 m, the confinement degradation was gradual compared with that at R_{ax}=3.6 m, although the confinement was lower at R_{ax}=3.75 m than at R_{ax}=3.6 m in the low density region. In this FY, difference of the density profile, which could influence the confinement, between tokamak and helical devices was focused. The particle transport can be expressed by a sum of neoclassical and turbulence transport and each transport can be divided into diagonal (diffusive) and off-diagonal (convective) terms. The diagonal term is generally dominated by turbulence transport in both tokamak and helical devices. The dominant transport for the off-diagonal term was discussed here.

The density profile was compared in the JT-60U ELMy H-mode plasmas (I_p=1.0 MA, B_T=2-2.1 T, P_{NB}=8-10 MW) and the LHD plasmas (B_T=1.5, 2.8 T) at various R_{ax} (3.5-3.9 m). In this report, the peaking factor of the density profile was defined as the ratio of the electron density at r/a=0.2 to that at r/a=0.8. In the JT-60U ELMy H-mode plasmas, the density peaking factor tends to decrease with increasing the electron density at r/a=0.5 as shown in Fig. 1 (a). In ASDEX-U and JET plasmas, the density peaking factor increased with decreasing an effective collisionality (ν_{eff}) defined as the ratio of electron-ion collision frequency to the curvature drift frequency[1),2)]. The curvature drift frequency of $\omega_{De}=2k_{\perp}\rho_s c_s/R$ provides an estimate of the growth rate of the most unstable mode for drift wave instabilities such as ion temperature gradient (ITG) mode and trapped electron mode (TEM). As shown in Fig. 1 (b), the same tendency as observed in ASDEX-U and JET was also observed in JT-60U, indicating that the off-diagonal term is determined by turbulence transport such as ITG and/or TEM. Here, $k_{\perp}\rho_s=\sqrt{0.1}$ was used for the estimation of ν_{eff}.

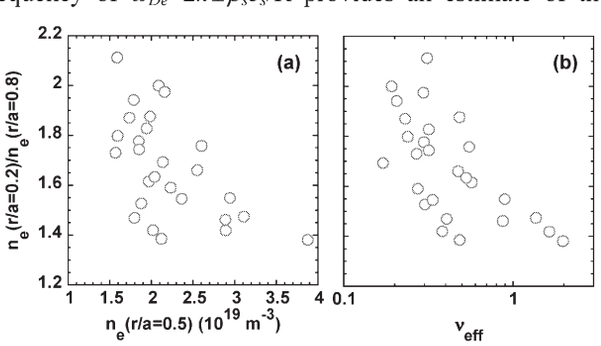

Fig. 1 Density peaking factor as functions of (a) the electron density at r/a=0.5 and (b) the effective collisionality in the JT-60U ELMy H-mode plasmas.

In the LHD plasmas, the density peaking factor was smaller than unity (hollow density profile) for a part of the data at R_{ax}=3.6 m and for all data at R_{ax}=3.75 and 3.9 m. The density peaking factor increased (the hollowness decreased) with increasing the electron density at r/a=0.5. This tendency can be qualitatively explained by increase in neoclassical off-diagonal term in $1/\nu$ regime for the helical system. On the other hand, the peaked density profile was observed at R_{ax}=3.5 m. The density peaking factor tends to decrease with increasing the electron density at r/a=0.5 as well as in JT-60U. The off-diagonal term could be affected by the turbulence transport at R_{ax}=3.5 m similar to tokamak plasmas. At R_{ax}=3.6 m, various density profiles were observed from hollow to peaked one. The data in the range of the electron density at r/a=0.5 of 1.2-1.6x10^{19} m^{-3} are plotted as a function of the central electron temperature. The density peaking factor decreased with increasing the central electron temperature and was separated for different B_T. This result might indicate that the dominant transport for the off-diagonal term changes depending on the ν regimes.

The dependence of the upper boundary for the density peaking factor on the electron density in the LHD plasmas at R_{ax}=3.5-3.6 m was similar as that in the JT-60U ELMy H-mode plasmas. In these LHD plasmas, the confinement degradation at high density was strong as well as in the JT-60U ELMy H-mode plasmas. These results might indicate common physics between tokamak and helical devices.

References

1) Angioni, G. et al., : Phys. Rev. Lett, 90 (2003) 205003.
2) Weisen, H. et al., : Nucl. Fusion 45 (2005) L1.

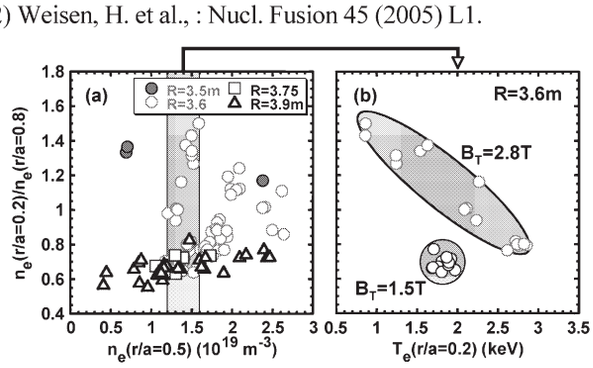

Fig. 2 Density peaking factor as functions of (a) the electron density at r/a=0.5 and (b) the central electron temperature (r/a=0.2) in the range of n_e(r/a=0.5)=1.2-1.6x10^{19} m^{-3} for the LHD plasmas.