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

Takenaga, H., Oyama, N., Konoshima, S., Takizuka, T., Fujita, T. (JAERI), Muraoka, K. (Chubu University), Tanaka, K., Yamada, H., Miyazawa, J., Peterson, B.J., Nishimura, K., Sakamoto, R.

A comparative study between tokamak and helical plasmas is beneficial for understanding of both common physics in toroidal system and unique physics depending on each magnetic configuration. In the last FY, the confinement degradation at high density in the LHD plasmas with R_{ax}=3.6 m was compared with that in the JT-60U ELMy H-mode plasmas. In this FY, the comparison was performed in the LHD plasmas with R_{ax}=3.75 m. For the particle transport, the gas-puffing modulation experiments were carried out in the last FY. In this FY, the particle transport was investigated with modulated ECH in the low density region, where it is difficult to use the gas-puffing modulation technique.

In LHD plasmas, an equivalent Greenwald density was estimated as $n_{GW}=(5/\pi)(B/R)\iota$, where ι at the LCFS was used. The dependence of confinement enhancement factor (τ_E/τ_{ISS95}) over the ISS95 scaling on n_e/n_{GW} at R_{ax}=3.6 and 3.75 m is shown in Fig. 1 (a). In LHD, n_e of ~1×10^{20} m^{-3} corresponds to n_e/n_{GW} of ~0.6 at R_{ax}=3.6 m and ~0.8 at R_{ax}=3.75 m. The value of τ_E/τ_{ISS95} decreased with increasing n_e/n_{GW} in the region of n_e/n_{GW}>0.1 at R_{ax}=3.6 m as reported in the last FY. The confinement improvement factor was smaller at R_{ax}=3.75 m than at R_{ax}=3.6 m in the region of n_e/n_{GW}=0.1-0.4. However, in the region of $n_e/n_{GW}\geq0.6$, it was larger at R_{ax}=3.75 m than at R_{ax}=3.6 m, because the confinement degradation was small at R_{ax}=3.75 m. In JT-60U ELMy H-mode plasmas, the confinement enhancement factor (H_{89P}) over ITER89P scaling decreased in the region of $n_e/n_{GW}\geq0.4$ as shown in Fig. 1 (b). In the outward shifted plasmas at R_p=3.6 m, the confinement degradation was also observed and H_{89P} was smaller than that at R_p=3.3 m. The effects of density profile and heating profile should be investigated in future work to understand the dependence of confinement on plasma configuration.

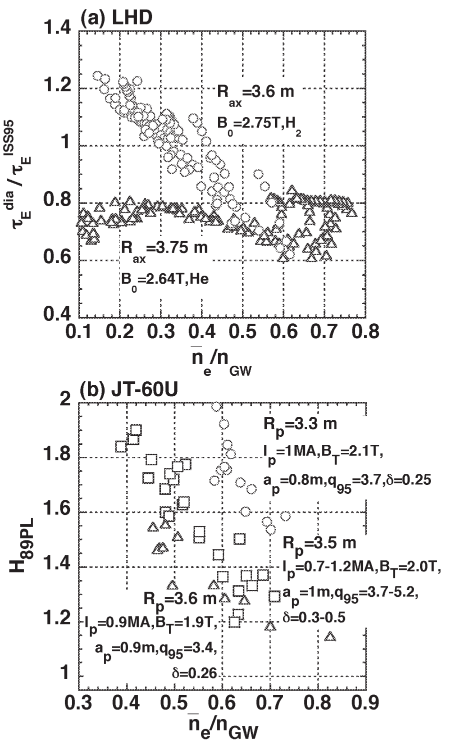

Fig. 1 Dependence of confinement enhancement factor on the density normalized by (equivalent) Greenwald density in (a) LHD and (b) JT-60U for different major radius.

The modulated ECH was applied in the low density plasmas with R_{ax}=3.5 m to investigate T_e and/or T_e gradient dependence of particle transport as shown in Fig. 2. The modulation was observed in the line integrated electron density and the central T_e. The modulation was also observed in the Hα emission intensity ($I_{H\alpha}$), which might indicate the modulation of the particle source. In fact, the density modulation propagated from the plasma edge to the plasma center, even with the central EC wave deposition as shown in Fig. 3. However, the phase of the modulated $I_{H\alpha}$ and edge density was reversed. The density modulation could be introduced by the T_e modulation rather than the modulation of the particle source. The density modulation was calculated with an assumption that the time scale of the heat transport is sufficiently shorter than that of the particle transport and changing rate of the temperature ($\Delta T_e/T_e$) is larger in the edge region. The calculation results with $D\propto T_e$ and $v\propto\nabla T_e$ indicates that the modulation propagates from the edge region to the central region as observed in experiment under this assumption (Fig. 3). Further study is necessary in future work to find the model, which gives better fitting to the experiment.

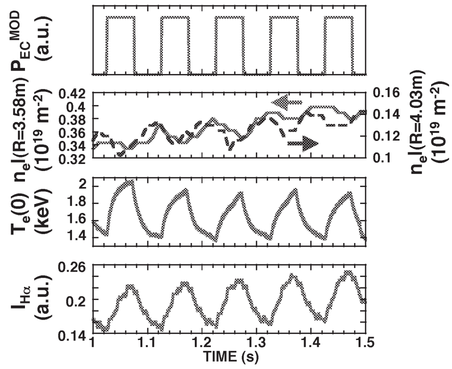

Fig. 2 Wave-forms of modulated ECH power, center and edge line integrated densities, center electron temperature and Hα emission intensity.

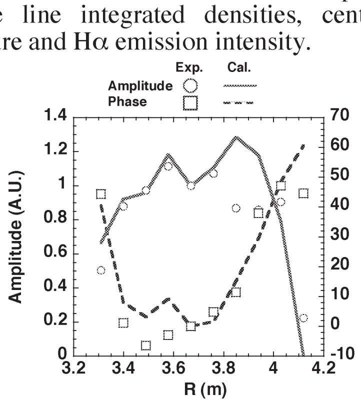

Fig. 3 Amplitude (circles : experiment, solid line : calculation) and phase difference (squares : experiment, dashed line : calculation) for modulated line integrated density.