§30. Improvement of Local Profile and Long-distance Correlation Diagnostic for the Turbulence Structure Analysis and its Application to the HJ-LHD Comparative Studies

Fukuda, T. (Osaka Univ.), Mukai, K., Nagasaki, K., Mizuuchi, T., Okada, H., Kobayashi, S., Yamamoto, S., Konoshima, S., Watanabe, S., Hosaka, K., Kowada, Y., Mihara, S., Lee, H.Y., Takabatake, Y., Kishi, S., Minami, K., Kondo, K., Sano, F. (Kyoto Univ.), Zhuravlev, V. (RRC Kurchatov)

As a result of the bilateral collaboration successfully performed in the past three years, detailed density profiles that enable the discussion of local gradient have become available with a microwave reflectometer [1-5] in Heliotron-J. Fig.1(a) shows the time evolution of the reconstructed profile in ECH heating plasma with standard configuration. During the heating phase, line averaged density measured by an interferometer ramped up from 0.6×10^{19} m^{-3} to 1.8×10^{19} m^{-3} as shown in Fig.1(b). The reconstructed profile clearly responds to an increase of averaged density, indicating that the gradient is significantly steep at the edge region. Sustainment of particle transport at a reasonable range at higher density or larger beta might have to do with the intrinsic equilibrium configuration pertaining to the Heliotron-J device. At low density around $\bar{n}_e = 0.6\times10^{19}$ m^{-3}, profiles can be measured over half the plasma confinement region, where it was documented that it has a hollow shape, similar to LHD plasmas with small major radii of typically <3.6m. The degree of hollowness is reduced with increasing averaged density, seemingly due to an increase of collision frequency and resulting decrease of particle diffusivity in the neoclassical frame. Although the density profile seems reasonable, however, a couple of problems remain. The density profile is reconstructed from the phase data after fitting by quartic function and subtraction of the offset data, calculated from the time delay due to group velocity in waveguide. One is that the reconstructed density is a little lower than the interferometer measurement. The other is that an artificial multiplier is implemented for density around LCFS. It may be due to errors in calibration, that is, the reference signal reflected from the vessel wall without plasma is too weak to use for calibration. Moreover, the offset data is not taken account, regarding the time delay effect in vacuum window. Further improvement, such as the application of Langmuir probe data may be necessary for more accurate profiles.

However, in the supersonic molecular beam injection experiment [6], which is considered to provide the particles directly into the confinement region, peaked profile is flattened, i.e., to $|a/L_n|$ of around 0.1 at ρ=0.6 right after the injection, followed by the gradual increase in 6ms. The characteristic time of response is comparable with global particle confinement time for Heliotron-J plasmas, and the behavior of $|a/L_n|$ is consistent with the H-alpha emission. Here, the frequency of AM reflectometer is scanned in 25ms, and the profile is reconstructed in 1ms. The scatter in the $|a/L_n|$ data is still large, and an increase of the integration time by a factor of 3-5 may provide significant improvement, though the resolution is degraded.

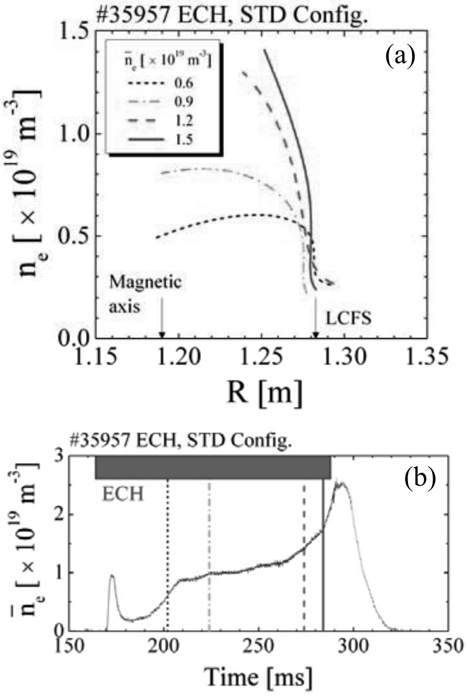

Fig.1 Temporal evolution of (a) reconstructed electron density profile and (b) line averaged density.

In regard to the simultaneous measurement of proposed turbulent fluctuations, additional microwave components have been installed in the torus hall and commissioned during the 2009 campaign, aimed at resolving the relationship between the local gradient and correlation characteristics. Although the contribution of $|a/L_T|$ is possible, an elaboration of the turbulent transport model is anticipated in a series of 2010 experiment.

[1] Laviron, C. et al.: Plasma Phys. Control. Fusion **38** 905 (1996).
[2] Mazzucato, E.: Rev. Sci. Instrum. **69** 2201 (1996).
[3] Hirsh, M., et al.: Rev. Sci. Instrum., **67** 1807 (1996).
[4] Estrada, T., et al.: Plasma Phys. Control. Fusion **43** 1535 (2001).
[5]Xiao, W. et al.: Plasma Science & Technology, Vol. **8**, No. 2 (2006).
[6] L. Yao et al.:Nucl. Fusion **47** (2007) 1399.