§13. Experiment to Measure Two-dimensional Potential Structure in Islands with HIBP

Shimizu, A., Ido, T., Nishiura, M. (Univ. Tokyo), Yokoyama, M., Takahashi, H., Igami, H., Kubo, S., Shimozuma, T., Kato, S., Yokota, M.

In the study of plasma confinement physics, measurement of the radial electric field, E_r, is very important, since poloidal plasma flow is correlated to $E \times B$ flow and turbulence suppression by shear flow is essential to improve the confinement property of devices. The plasma flow is also important for physics of 3-D magnetic field configuration, such as island formation, its healing [1], and stochastic character [2]. To study these physics in LHD, the method of 2-D potential profile measurement with HIBP has been developed and 2-D potential structure in islands was tried to be measured.

In order to 2-D potential profile structure, the prove beam energy, E_b, is needed to be changed. It is not easy to change the probe beam energy because that LHD-HIBP system has a long beam transport line (~20m) and many electro-static deflectors should be adjusted to optimize the beam orbit on the beam transport line, when E_b is changed. To reduce the required time for this adjustment, the PC based automatic adjustment system was developed. By using this system, 2-D potential profile was successfully measured [3]. In the recent experiment, 2-D potential structure in islands was tried to be measured.

In previous experiments, one dimensional potential profile in islands was measured as shown in Fig.1. For reference, the electron temperature profile measured with Thomson scattering diagnostic is also shown in this figure. The flat potential profile is clearly seen in the region, $0.2 < r_{eff} / a_{99} < 0.5$. In the temperature profile, the flat region is roughly $0.25 < r_{eff} / a_{99} < 0.6$, of which region almost coincides with a flat region in potential profile. The flat region in electron temperature is not symmetric with respect to the magnetic axis. It is considered that the phase of islands make effects on this asymmetry.

To measure 2-D potential profile in islands, the probe beam energy, E_b, was changed shot to shot in experimental series. In this experiment, rmp field was applied to enlarge the size of $m / n = 2 / 1$ islands. Experimental results are shown in Fig.2. Unfortunately, only 4 effective shots were obtained because the effect of rmp field on the probe beam orbit was large and additional adjustment of beam was required. For the reference, magnetic surfaces with islands on the vacuum condition are shown in the figure. (The plasma response to magnetic surfaces is not considered.) The 2-D potential structure in islands are not seen clearly, since reproducibility of these 4 shots are not good, and 4 shots are not enough to deduce the 2-D potential profile in islands. However, in the shot #126916, the flat potential profile in islands is partially seen as shown in Fig. 3 although S/N ratio is not good. In Fig.3, the electron temperature profile is also shown, in which the flat area is not large compared with in Fig.1. It is considered that the plasma response may reduce the size of islands. More shots to obtain clear 2-D potential profile in islands are required, and experiments with good S/N ratio will be done in the future.

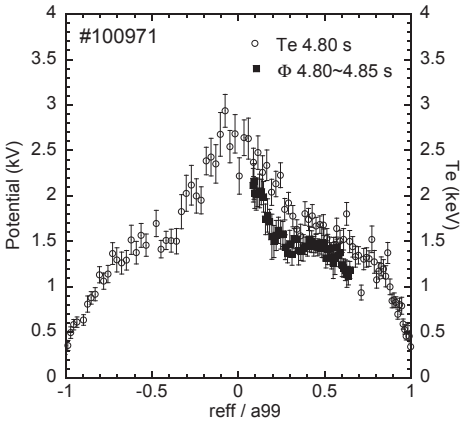

Fig. 1. Potential and electron temperature profile when islands appeared.

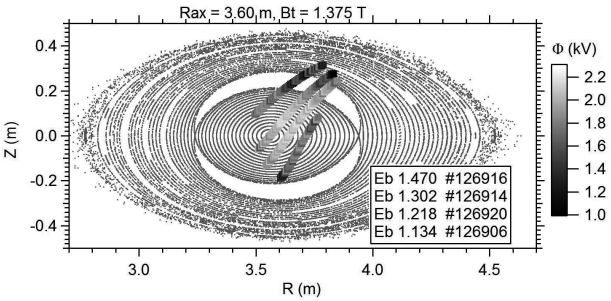

Fig. 2. Experimental result to measure 2-D potential profile in $m/n = 2/1$ islands.

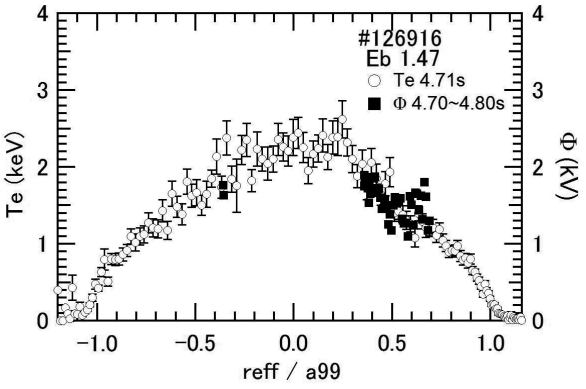

Fig. 3. Potential profile and electron temperature profile of shot #126916.

1) Narushima, Y. et al.: Nucl. Fusion **51** (2011) 083030.
2) Ida, K. et al.: Nature Communications **6** (2015) 5816.
3) Shimizu, A., Ido, T., Kurachi, M. et al.: Rev. Sci. Instrum. **85** (2014) 11D853.