§6. Experimental Study of Compatibility of a Transport Barrier and Energetic Ion Confinement

Sasao, M., Utoh, H., Nishimura, H., Kitajima, S., Shinto, K., Okamoto, M., Takahashi, H., Tanaka, Y. (Tohoku Univ.),
Ogawa, H. (JAERI),
Takayama, M. (Akita Pref. Univ.),
Nishimura, K., Osakabe, M., Nagayama, Y., Isobe, M., Nishiura, M., Inagaki, S., Yokoyama, M.

The confinement of energetic ions is one of key issues for the prospect to a steady state reactor plasma using a helical system[1]. Complex motions of trapped particles in helical systems tend to enhance the radial transport. It has been known that a radial electric field might effect on the confinement of energetic particles, while it play an important role to form transport barriers and to realize improved modes. In this Joint Research, we study the compatibility of a transport barrier and energetic ion confinement in helical systems.

In order to study the effect of a radial electric field, E_r, on the energetic particle confinement in LHD, four types of E_r profile (shown in fig. 1) were assumed and the orbit calculation were performed. In fig. 2 are shown some examples of the results, for 50 keV passing protons in the R_x = 3.6 [m] and B = 2.829 [T]. Although the effect is small, there is obvious change in the orbit after several toroidal rotation.

In the Tohoku University Heliac (TU-Heliac), the influence of a radial electric field on the improved modes has been investigated in both positive and negative biasing experiments by using various types of electrode, such as a stainless steel (SUS) electrod, an electron emission hot cathode[2], or a Titanium electrode[3].

In this academic year, a Vanadium electrode was developed. When it was biased negatively after treatment, the high-density plasma was produced, similarly to the Titanium electrode experiment. High-density plasma production was observed up to 24 times with the V electrode after one treatment, and it was observed in not only Ar plasmas but also He plasmas. The electrode current, I_E, increased up to about 100 A and the line electron density, $n_e l$, and the electron density, n_e, increased by about 5-fold as compared with those before biasing. Figure 3 shows the radial profiles of the electron density and radial electric field in the V electrode biasing experiments both before (solid circles) and during biasing (open triangles) in the He plasma. With V electrode biasing, the radial distribution of the electron density sloped steeply at the electrode position and a strong negative radial electric field was formed outside the electrode. It is expected that high-density plasma will be observed in the hydrogen plasma. The $E \times B$ drift velocity was calculated from the local electric field, which was about 30 km/s, and the Mach number, M_p, was estimated to be M_p –20. This M_p was 5-fold larger than that obtained in low-density H mode.

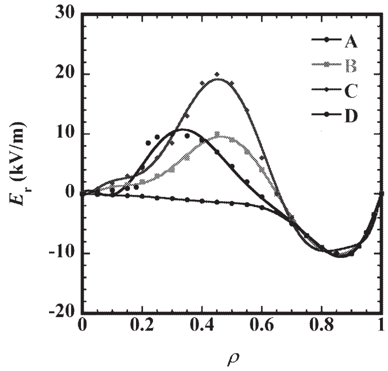

Fig. 1. The E_r profiles assumed for the orbit calculation in LHD.

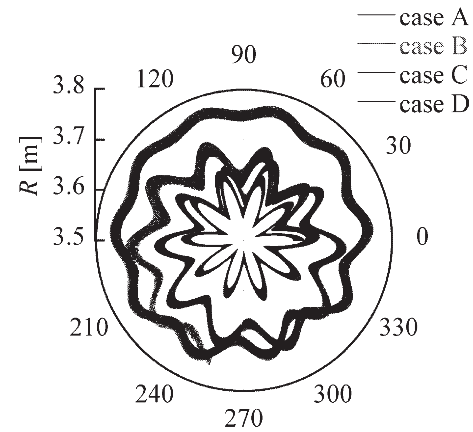

Fig. 2. Examples of the effect of E_r profiles (Fig. 1), on 50 keV passing proton orbits in the LHD configuration of R_x = 3.6 [m] and B = 2.829 [T].

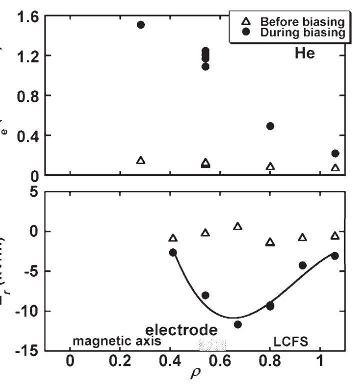

Fig. 3. The radial profiles of the electron density, n_e and radial electric field, E_r in the V electrode biasing experiments.

References
[1] Sasao, M. et al., Proceedings of 18 IAEA Fusion Energy Conference, IAEA-CN-77/EX9/1(Sorento, October 2000).
[2] Kitajima, S. *et al.* Proceedings of 20 IAEA Fusion Energy Conference, IAEA-CN-116/EX/9-3(October 2004).
[3] Utoh, H. *et al.* Proceedings of EPS2005 (P2.006).