§20. Radial Electric Field Control by Electrode Biasing in Heliotron J

Kitajima, S., Sasao, M., Okamoto, A., Sato, J., Ishii, K. (Dept. Eng. Tohoku Univ.), Takayama, M. (Akita Prefectural Univ.), Sano, F., Mizuuchi, T., Nagasaki, K., Okada, H., Kobayashi, S., Yamamoto, S. (Kyoto Univ.), Suzuki, Y., Yokoyama, M., Takahashi, H.

The radial electric field control experiments were carried out by an electrode biasing in Heliotron J. In L–H transition theories, the local maximum in ion viscosity versus poloidal Mach number M_p around $-M_p \sim 1$–3 is considered to play a key role$^{1)}$. This maximum is considered to be related to Fourier components of a magnetic configuration. In the Tohoku University Heliac (TU-Heliac), the effects of the viscosity maxima on the L-H transition have been experimentally investigated. The poloidal viscosity was estimated from the $\boldsymbol{J} \times \boldsymbol{B}$ driving force for a plasma poloidal rotation, where $\boldsymbol{J}$ was a radial current controlled externally by the LaB_6 hot cathode biasing. It was experimentally confirmed that the local maxima in the viscosity play the important role in the L-H transition$^{2\text{-}3)}$. Therefore it is important to perform this biasing experiments mentioned above in the confinement system that has changeability of the Fourier components of the magnetic configurations. The purposes of our electrode biasing experiments in Heliotron J were, (1) to estimate the ion viscous damping force from the driving force for the poloidal rotation, and (2) to study the dependence of the ion viscosity on helical ripples and bumpiness.

In the biasing experiments in Heliotron J, the H_2 and D_2 target plasmas were produced by the ECH of 2.45 GHz ($P_{max} \sim 4$kW). We used the hot cathode made of LaB_6 to bias the target plasmas. Figure 1 shows the time evolutions of electrode voltage V_E, electrode current I_E, electron temperature T_e, electron density n_e, plasma potential V_s and fluctuation in the floating potential measured by the triple probe. In this campaign we used a higher power supply (650V 23A CW) for an electrode biasing and can externally control the biasing voltage by a function generator. The electrode voltage was applied by the triangle waveform in order to clarify the transition point. At $t \sim 1$ s we can see the transition point to the improved mode and after this point the electron density increased by about 3 times and the deep plasma potential was formed and the fluctuation level was suppressed. At $t \sim 2.2$ s the back transition point also appeared and plasma parameters returned the value before the transition. We compared the driving force with the neoclassical theory$^{1)}$. Figure 2 shows the relation between the poloidal Mach number M_p and the normalized driving force F_{driv}. In these estimations we supposed the $T_i/T_e \sim 1$. The normalized driving force was larger than the neoclassical value, however the dependence of the viscosity on the poloidal Mach number qualitatively agreed with the theoretical prediction.

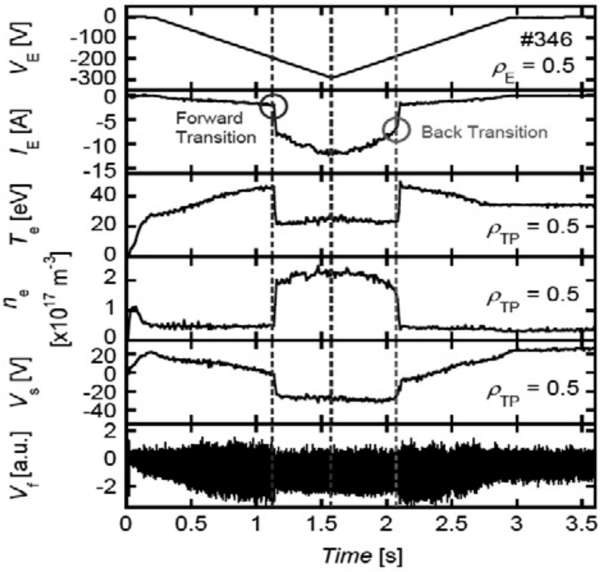

Fig. 1. Time evolutions of electrode voltage V_E, electrode current I_E, electron temperature T_e, electron density n_e, plasma potential V_s and fluctuation in the floating potential measured by the triple probe.

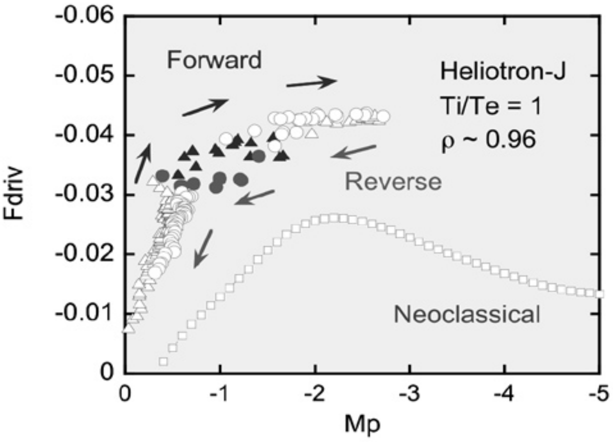

Fig. 2. Relation between the poloidal Mach number M_p and the normalized driving force F_{driv}.

1) Shaing K. C.: Phys Rev. Lett. **76**, 4364 (1996).

2) Kitajima, S., *et al.*: Nucl. Fusion, **46**, 200-206 (2006).

3) Kitajima, S., Takahashi, H. *et al.*: Nuclear Fusion, **48** (2008) 035002.