§12. Investigation of the Configuration Dependence of the Poloidal Torque Using Biased Electrode for the LHD Plasmas

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An electrode biasing experiment is one of the active control methods of radial electric field. The electrode biasing experiment has the advantage of ability to control radial electric field externally by controlling the electrode voltage and/or the electrode current and to estimate the driving force from the electrode current. Electrode biasing experiments have been carried out in the LHD in order to investigate the behavior of neoclassical poloidal viscosity[1),2)]. In the LHD, effective magnetic ripple increases in the outward configuration. Neoclassical theory predicted that the poloidal viscosity increases with the amplitude of the magnetic Fourier components (the weight depends on the Fourier mode)[3)]. Thus the poloidal viscosity in the LHD is considered to be increased in the outward configuration. In order to verify the dependence of the poloidal viscosity on the magnetic ripple structure, the biasing experiments in various configurations is needed.

Figure 1 shows the relation between the bias voltage V_E and the electrode current I_E for five configurations. The transition of the poloidal torque has been observed in the configurations of R_{ax} = 3.53, 3.60, 3.65 and 3.75 m and the torque required for the transition increased in the outward configuration. On the other hand, the transition of the poloidal torque has not been confirmed in the outward configuration of R_{ax} = 3.9 m in the operational range of the power supply used for the electrode biasing (maximum output voltage and current are 1 kV and 18 A, respectively). This means that poloidal viscosity of the configuration of R_{ax} = 3.9 m is larger than those of the other configurations and larger torque is required for the transition.

Although the transition was not observed in the case of R_{ax} = 3.9 m, the radial conductivity can be compared among all configurations in the L mode condition. Figure 2 shows the configuration dependence of the radial conductivity and the increment of the poloidal viscosity $\Pi_{p,n}$ against the poloidal Mach number M_p in the L mode plasmas. Here the poloidal viscosity was calculated using the FORTEC-3D code[4)]. Note that the poloidal viscosity is balanced with the poloidal torque of J_rxB_t and the poloidal velocity V_θ can be written using E_r when E_rxB_t flow is dominant for V_θ. Thus $\delta\Pi_{p,n}/\delta M_p$ is comparable parameter with the plasma radial conductivity. As can be seen from fig. 2, both the experimental conductivity and $d\Pi_{p,n}/dM_p$ increased in the outward configuration. This indicates that the larger torque is required to produce the poloidal flow velocity in the outward configuration.

From the results above, it is said that the tendency of the configuration dependence of the critical torque and the conductivity qualitatively agreed with the prediction of the neoclassical theory.

1) Kitajima, S. et al.: Nucl. Fusion, **51** (2011) 083029.
2) Kitajima, S. et al.: Nucl. Fusion, **53** (2013) 073014.
3) Shaing, K.C.: Phys. Rev. Lett. **76** (1996) 4346.
4) Satake, S. et al.: Plasma Phys. Control Fusion, **5 3** (2011) 054018.

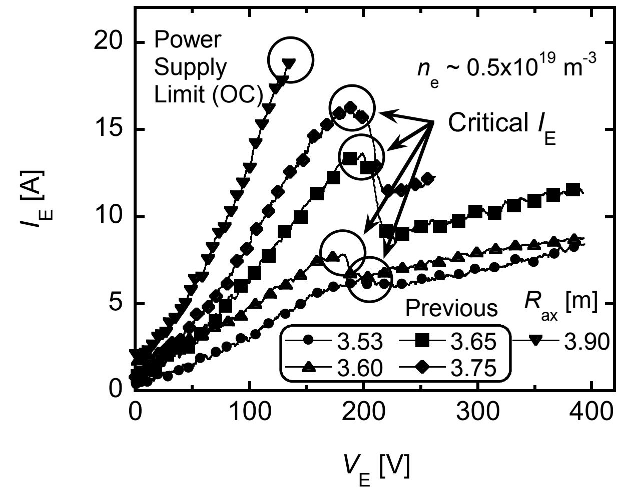

Figure 1. The relation between the bias voltage V_E and the electrode current I_E for five configurations.

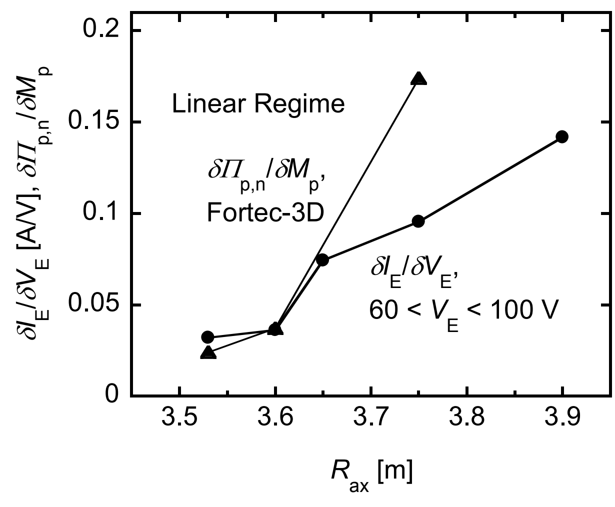

Figure 2. The configuration dependence of the radial conductivity and the increment of the poloidal viscosity $\Pi_{p,n}$ against the poloidal Mach number M_p in the L mode plasmas.