§30. Verification of Role for Poloidal Ion Viscosity in Transition to Improved Mode in Heliotron J

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In order to verify a role of neoclassical ion viscosity for a transition to high confinement mode, electrode biasing experiments were carried out in the Heliotron J. In the research, the dependence of the transition criterion on the ripple structure was evaluated in four helical devices and compared among them.

Figure 1 shows the dependence of the normalized poloidal driving force F_{jxB} on the poloidal Mach number M_p. The experiment was performed under the magnetic configuration of R_{ax} = 1.2 m, B_t = 0.1 T. In the experiments, the plasma was produced and sustained by 2.45 GHz ECRH. The electrode made of LaB_6 was set at ρ = 0.96 and the negative bias voltage of the triangular waveform was applied to it against the vacuum vessel. The forward/backward transitions were observed in the voltage ramp-up/down phase. In fig. 1, the triangle and the circle symbols are the data in the voltage ramp-up and down phase, respectively. The solid symbols are the data in the transition phase and correspond to the critical driving force for the transition. The square symbols in the figure are the poloidal ion viscosity F_{visc} calculated using Shaing model.[1] Neoclassical theories indicated that plasma makes a transition to an improved mode when the momentum driving force in poloidal direction exceeds the local maxima in the ion viscosity. However the experimental data in the transition region (solid symbols) were 1.3 times larger than the local maximum value of the ion viscosity. It implies that the neutral particles considerably existed in the target plasma and the momentum drag effect through the charge exchange process was not negligible. Consequently the driving force required for the transition was thought to be increased.

Figure 2 shows (a) the relation between the driving force required for the transition F_{C_EXP} and the local maximum value of the poloidal ion viscosity calculated using Shaing model F_{LM_CAL}, (b) the dependence of F_{C_EXP} and F_{LM_CAL} on the effective helical ripple ε_{eff} for the Heliotron J, the Tohoku University Heliac (TU-Heliac), the Compact Helical System (CHS) and the Large Helical Device (LHD). ε_{eff} were calculated using DCOM for TU-Heliac and Heliotron J, GIOTA for CHS and NEO2 for LHD. Figure 2 (a) shows that F_{C_EXP} qualitatively agreed with F_{LM_CAL} implying that the transition criterion can be predicted by Shaing model. In addition, positive correlation between F_{C_EXP} (F_{LM_CAL}) and ε_{eff} was observed as shown in fig. 2 (b), therefore ε_{eff} is considered to be an appropriate parameter for comparative study of the electrode biasing experiments in several devices.

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

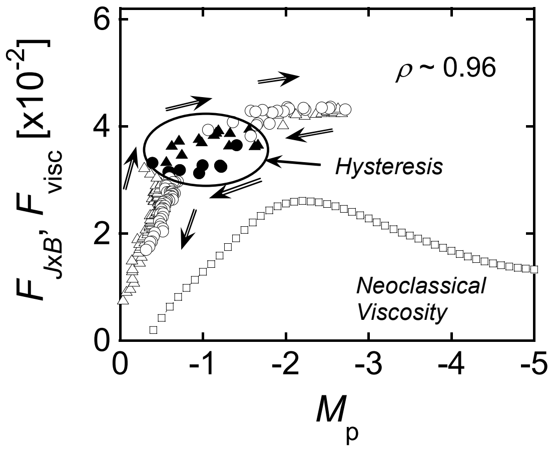

Fig. 1. The dependence of the normalized poloidal driving force F_{jxB} on the poloidal Mach number M_p

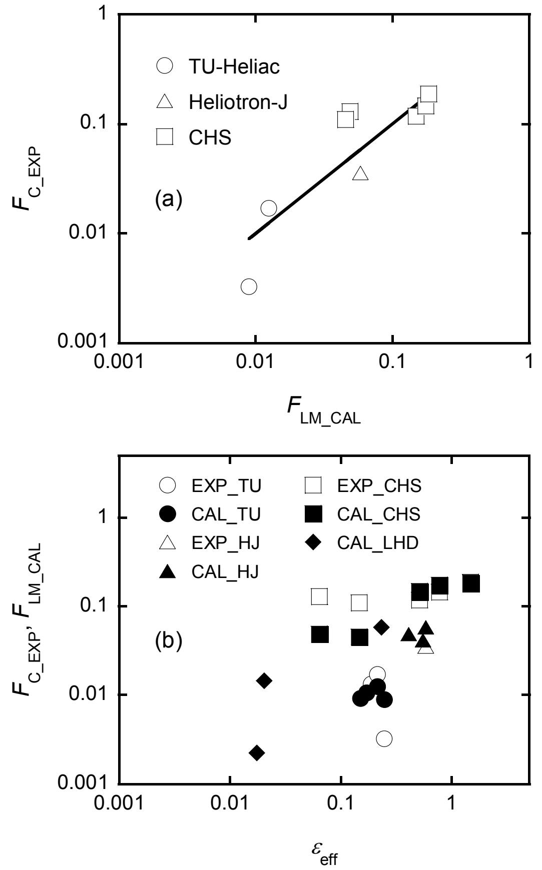

Fig. 2. (a) the relation between F_{C_EXP} and F_{LM_CAL}, (b) the dependence of F_{C_EXP} and F_{LM_CAL} on ε_{eff} for the Heliotron J, TU-Heliac, CHS and LHD