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

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In the Tohoku University Heliac (TU-Heliac), we successfully observed the bifurcation of a radial electric field by a LaB_6 hot cathode biasing. The poloidal viscosity was estimated from the $\boldsymbol{J} \times \boldsymbol{B}$ external driving force for a plasma poloidal rotation, where $\boldsymbol{J}$ was a radial current controlled externally by the LaB_6 hot cathode biasing, and the deduced viscosity was qualitatively agreed with the neo-classical viscosity. [1, 2] In L–H transition theories, the local maximum in ion viscosity versus poloidal Mach number plays a key role.[3] This maximum is considered to depend on Fourier components of a magnetic configuration. 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 campaign (2010 ~ 2012) we made the magnetic configuration database in Heliotron J to survey the dependence of transition condition on magnetic configuration. We selected 3 configurations and tried biasing experiments to the target plasma produced by the ECH (f = 2.45 GHz P_{max} ~ 19 kW). We successfully obtained the dependence of transition condition on magnetic configurations. Figure 1 shows the dependence of transition condition (driving force at transition) on the effective ripple ε_{eff} in various stellarator devices. Open symbols denote calculated data, which have linear dependence to ε_{eff}. Biasing experiments in Heliotron J were performed in low magnetic filed configurations. Therefore we still did not make the best use of the configuration flexibility in Heliotron J. In the campaign (2012) we also observed the intermittent increase in the electrode current in the magnetic configuration (DCC). Figure 2 shows the time evolutions of the electrode voltage, the electrode current, the electron density, the electron temperature, the floating and the space potential. It clearly shows that the electrode current, density and temperature play the periodic feature and reveals the periodic transition from L mode to improved confinement mode.

In this campaign (2013) in order to solve the restriction on flexibility in magnetic configurations selected for the biasing experiments in a low magnetic field and to perform direct measurements of an ion temperature and a flow velocity, we discussed the following points:

1) flexibility in the magnetic configuration in a high magnetic field (standard operation in Heliotron J),
2) robust electrode made of carbon or hydrogen absorbing alloy for the electrode biasing in the high magnetic field,
3) direct measurements of an ion temperature and a flow velocity by a spectroscopy,
and designed and manufactured electrodes and improved an electrode driving system.

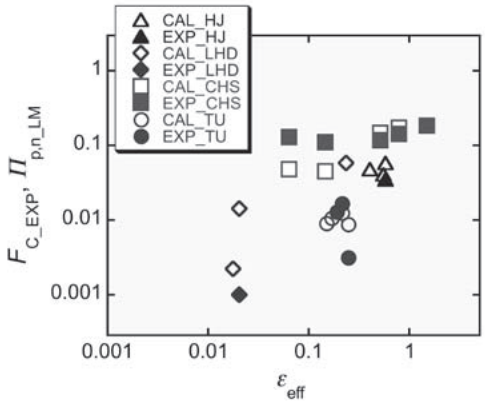

Fig. 1 Dependence of transition condition (driving force at transition (closed symbols) and viscosity at local maxima (open symbols)) on the effective ripple ε_{eff} in various stellarator devices

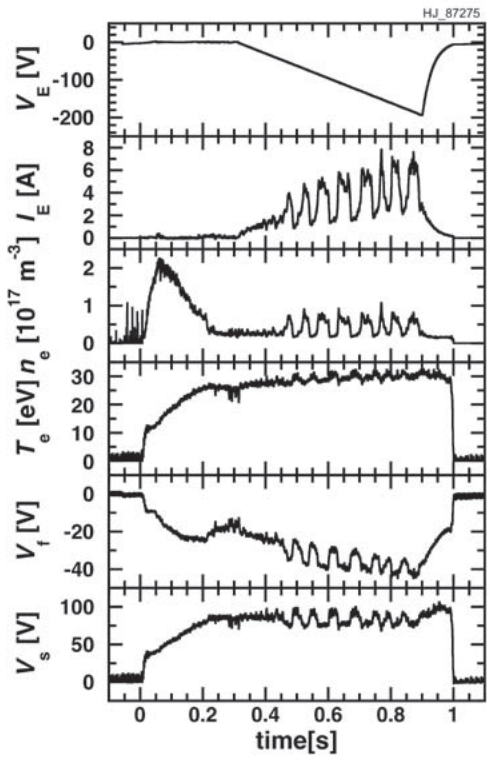

Fig. 2 Time evolutions of the electrode voltage, the electrode current, the electron density, the electron temperature, the floating and the space potential

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2) Kitajima, S., Takahashi, H. *et al*.: Nuclear Fusion, **48** (2008) 035002.
3) Shaing K. C.: Phys Rev. Lett. **76**, (1996) 4364.