§19. Study of Interaction between Magnetic Island and Plasma Flow using Electrode Biasing Method

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The effect of the viscosity on the magnetic island changing the plasma rotation is experimentally investigated. The poloidal rotation is externally controlled by the hot cathode biasing.

In the LHD experiment, the self-healing of the magnetic island is observed. That is, the static magnetic island produced by external perturbation coils is suppressed by the plasma response. A question is why the magnetic island appears or disappears. One idea is an interaction between the plasma rotation and external perturbation. If the plasma is rotaing, the external perturbation is shielded out by the singular current on a resonant surface. This singular current is driven by the perpendicular viscosity on the rational surface. This effect is well knwon in tokamak experiments as "the kinetic shielding". Recently, this idea is extended to the helical plasma. Then, changing of the poloidal rotation was observed at the self-healing of the island in the LHD experiment. This means the understanding relation between the external perturbation and plasma viscosity is a critical issue. We need consider the relation in the experiment.

On the other hand, the poloidal rotation is very sensitive to the external magnetic perturbation. That means there is a possibility to identifiy the magnetic island or stochastic magentic field lines from the measurement of the poloidal rotation.

In the LHD expeirment, the electrode biasing was used to study the transition to the improved confinemnt. Superposing the current from the electrode to the plasma, the plasma rotation can be controlled by $\mathbf{J} \times \mathbf{B}$ driving force. This is alos the electrode biasing can be used as a nob to control the plasma rotation. In this contribution, we study the relation between the magnetic island and poloidal plasma rotation. The LHD configuration has an intrinsic magnetic island because the error field by the construction error of poloidal field coils is expected. Usually, that intrinsic error field can be cancelled by external Resonant Magnetic Perturbation (RMP) coils. The error field is estimated by a MonteCarlo simulation. However, if we measure the transition of the torque of the electrode biasing, we may detect differences of the transition due to changing external RMPs. Changing the magnetic island width of RMPs, the transition is studied.

The target plasma for the biasing in LHD was produced by ECH (f=77 and 84 GHz, $0.2 < P_{\mathrm{ECH}} < 0.5$ MW) in magnetic configurations (R_{ax} = 3.60 m, B_t = 1.375 T). The electron density and temperature at the magnetic axis were $0.8 \times 10^{18} m^{-3}$ and $\sim$ 1 keV in the Helium target plasma. The electrode was a cylindrical disk of diameter 100 mm and length 40 mm, made of Carbon and inserted to $\rho \sim 0.8$. The RMP field is superposed with (m, n)=(2,1) modes.

Figure 1 shows the response of (m, n)=(1,1) and (2,1) for the electrode biasing experiment with external RMPs. Red lines indicate timings of turn on and off of the electrode biasing. In the time turned on the electrode biasing, the response of (2,1) does not change but the response of (1,1) increases slightly. Figure 2 shows the plasma rotation measured by the reflectometer. At the same time with the response, the plasma rotation changes clearly with the RMP. This suggests the magnetic island can be worked as the viscosity to damp the rotation. As a next step, we will compare the experimental results to the theory.

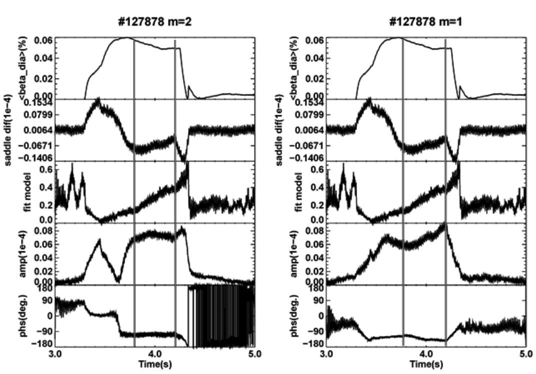

Fig. 1: The response of (m, n)=(2,1) and (1,1) is shown. The response is measured by the flux loop array.

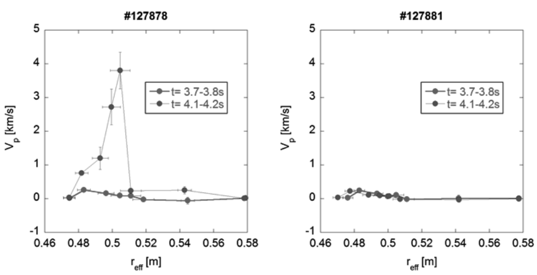

Fig. 2: Profiles of the poloidal plasma rotation measured by the reflectometer are shown with and w/o the RMP. For the case with the RMP (#127881), the poloidal rotation is damped clearly.