§37. Experimental Study of MHD Mode Rotation in the Edge Plasmas of the Large Helical Device

Takemura, Y. (Grad. Univ. Advanced Studies),
Sakakibara, S., Watanabe, K.Y., Ida, K.

The relationship between MHD mode rotation and the plasma flow has been investigated on Large Helical Device (LHD). Understanding of characteristics of MHD modes is one of a key issue for its control, which is required to produce high beta plasma. In the heliotron configuration without net current, an interchange mode is one of key instabilities because of magnetic hill formation and the onset and parameter dependence of the mode have been investigated in various configurations.[1)] Especially, the modes excited in the periphery are dominantly observed when the beta increases and/or L/H transition occurs. Several modes are excited in the stochastic layer and the previous studies suggest that they are key instabilities for degradation of high beta plasma and/or the formation of the edge transport barrier. Here it is focused on the rotation frequencies of observed MHD modes in currentless helical plasma. It is widely known in tokamaks that MHD mode rotation is a key for maintaining the "stable" plasma state. In the case of tearing mode, reduction of the plasma flow induces the mode locking, leading the disruption finally. Also, since the resistive wall mode, which limits the achieved beta, is destabilized by insufficient plasma flow, an external momentum input is required to maintain high-beta plasma. In the helical plasmas, no major disruption occurs, whereas the interchange modes sometimes affect the plasma profile around the resonances. The effect of the plasma flow on the interchange instability should be clarified to improve the plasma performance.

The electron density scan experiment was performed in order to widely change the radial electric field and poloidal flow. The experimental parameters were set as follows: toroidal magnetic field B_t = -1.75 T and magnetic axis R_{ax} = 3.60 m. The port-though power of NBI is constant. The averaged beta value is about 1.5 %. Figure 1 shows changes of rotation frequencies of m/n = 1/1, 3/4 and 2/3 modes (ω_{MHD}), poloidal flow (ω_θ), toroidal flow (ω_ϕ) and electron diamagnetic frequency (ω_e^*) as a function of electron density. The ω_θ, ω_ϕ and ω_e^* were on each resonant surface. The positive sign corresponds to the ion diamagnetic direction.

The equilibrium calculation shows that resonances of *m*/*n* = 1/1 and 3/4 modes are located in the periphery but inside the last closed flux surface (LCFS) and *m*/*n* = 2/3 resonance is just outside the LCFS, that is, stochastic layer. These modes rotate in the electron diamagnetic direction with several kHz in the laboratory frame and the frequencies gradually decrease with the density. Toroidal flow is almost zero at any resonance, which is quite different from tokamaks.

Experimental results suggest that any "pure" MHD frequency in the plasma frame is quantitatively consistent with the electron diamagnetic drift frequency within the measurement error. This means that the observed modes freeze the electron fluid as well as tearing mode.[2)] In this experiments, there is no significant difference between MHD modes inside/outside the LCFS. In the high beta plasmas with more than 3 %, the modes where the resonance is clearly located at the core of stochastic layer, such as *m*/*n* = 1/2, 2/5 and so on, have been dominantly observed.[3)] The further experiments are expected to clarify the characteristics of the stochastic modes.

1) S.Sakakibara et al., Fusion Sci. Technol. 58 (2010) 176-185.
2) O. Klüber et al., Nucl. Fusion 31 (1991) 907.
3) A. Komori et al., Phys. Plasmas 12 (2005) 056122.

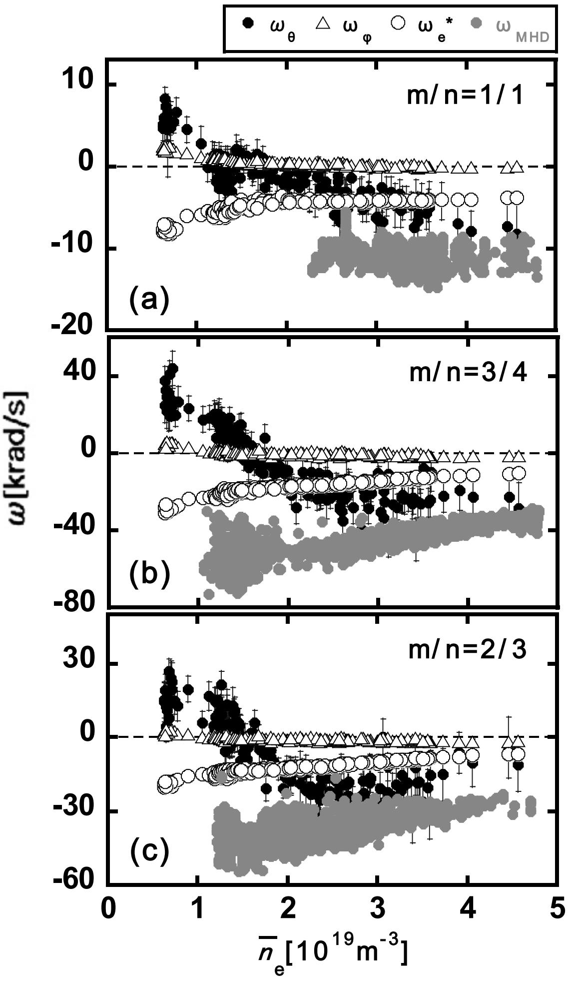

Fig. 1. Changes of rotation frequencies of poloidal plasma flow(ω_θ), toroidal plasma flow (ω_ϕ), (a) *m*/*n*=1/1, (b)3/4, (c)2/3 modes (ω_{MHD}) and electron diamagnetic frequeincy (ω_e^*) as a function of electron density. The positive sign corresponds to the ion diamagnetic direction.