§11. Rotation of Interchange Instability in the Large Helical Device

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An interchange mode, which is one of important instabilities in helical plasmas, has been experimentally and theoretically investigated for a long time to understand the characteristics and the effect on the plasma confinement. However, experimental and theoretical knowledge on rotation of the interchange mode is still insufficient. The experimental study on the mode frequency is important, as well as tokamaks, in order to consider the stability control in the future. In this paper, the results of the comparison between the rotation of interchange mode and the plasma flow in the Large Helical Device (LHD) with various condition of the plasma are described. Especially, we focus on the mode excited in the periphery of the plasma because the peripheral modes are dominantly observed in wide beta range and they are key instabilities in the high-beta state in heliotron configurations.

Figure 1 shows the MHD activities in typical discharge with $<\beta_{dia}>$ of 1.5 %. The two co- and one counter NBs are applied at 3.3-4.8s to produce and maintain the plasma. The port through power of NBs is about 20 MW. The $<\beta_{dia}>$ was almost constant during a discharge, while the line averaged electron density was ramped up to 5×10^{19} m^{-3}. The m/n = 3/4 and 1/1 modes were dominantly observed and rotated in the electron diamagnetic direction in the laboratory flame. The m/n = 3/4 mode firstly appeared at the beginning of the discharge, and the frequency increases with build-up of $<\beta_{dia}>$. When the $<\beta_{dia}>$ exceeded about 1 %, the frequency approached about 60 krad/s and decreased with an increment of the density. The m/n = 1/1 mode appeared at 3.52s when the density exceeded a certain value. The frequency of the m/n = 1/1 mode was almost constant to about 10 krad/s. After the excitation of both modes, they continue to appear until the end of the discharge.

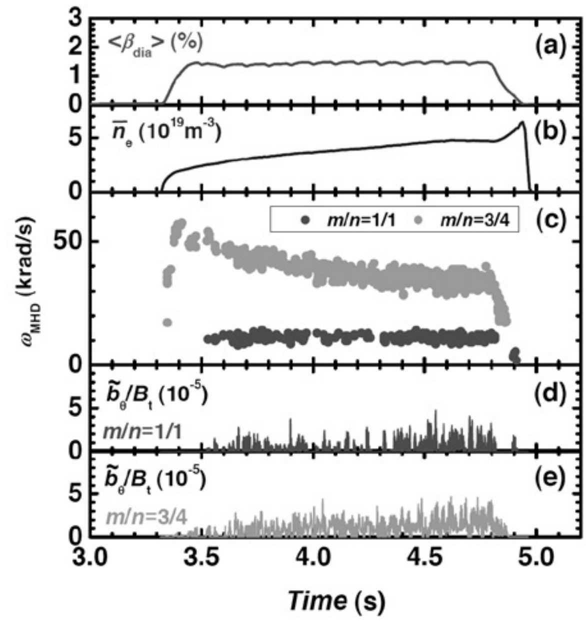

Fig. 1. MHD activities in the discharge with $<\beta_{dia}>$ ~ 1.5 %. (a) the volume averaged beta value, (b) line averaged electron density, (c) angular frequencies of MHD modes, amplitudes of (d) m/n = 1/1 and (e) 3/4 modes.

In order to compare with the plasma flow in the wide frequency range, we changed the tangential NB direction by changing the polarity of the toroidal magnetic filed because the toroidal momentum is driven by the NBs. In addition, the electron density was also changed in the range of 2.4 to 4.8×10^{19} m^{-3} so as to change the radial electric field related with the E×B flows because the formation of the radial electric field is sensitive to the density. The mode frequencies also depend on the density as shown in Fig.1. Figure 2 shows the comparison of the angular frequencies of observed modes and the ion/electron flows. It is assumed that the ion (electron) flows consist of E×B drift flow and ion (electron) diamagnetic drift one. The positive frequency corresponds to the electron diamagnetic direction. The E×B flows obtained in the experiments were in the electron diamagnetic direction, and the electron flow with $\omega_{E\times B}$ + ω_e* could be widely changed. The experimental results show that the frequencies of the electron flows are quantitatively agreement with those of m/n = 1/1 (with < 20 krad/s) and 3/4 (with > 20 krad/s) modes.

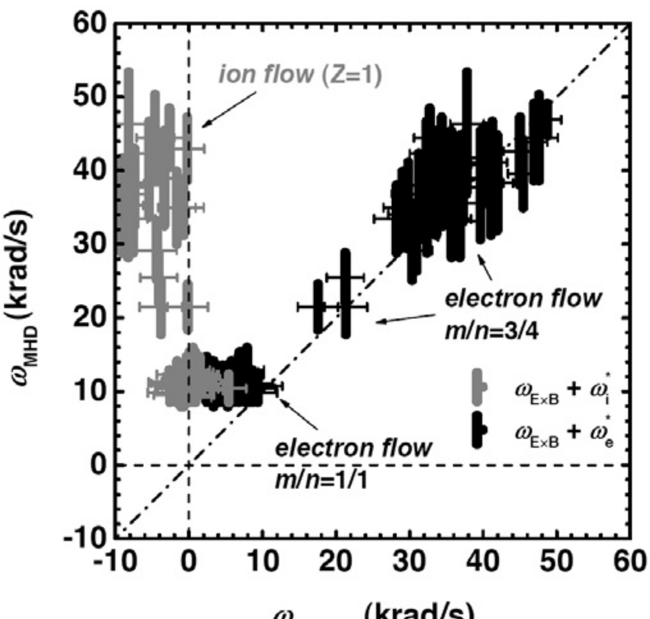

Fig. 2. Comparison between angular frequencies of m/n = 1/1 and 3/4 mode and the electron/ion flows obtained in different electron density plasmas.