§31. Effect of Magnetic Shear on the Confinement Performance through Interchange Instability

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The aim of this study is to get the knowledge on the effects of the magnetic shear on the confinement through the interchange instability by comparison the impacts of the interchange instability on the degradation level of the confinement performance in between LHD and Heliotron-J because the characteristics of the magnetic shear of Heliotron-J are quite different from those of LHD. According to the linear theory, the mode width and the growth rate are larger as the magnetic shear increases. However, the impact of the magnetic shear on the confinement due the interchange instability is not clear because the systematic researches on the mode width and the fluctuation levels in a saturated state of the instability are a few. In our previous works on the LHD, we found that when the amplitude of the radial displacement is 5%, the confinement performance normalized by ISS04 scaling is reduced by about 10% [1].

As the next step, we evaluate the degradation level of the confinement performance when the MHD instabilities occur in Heliotron-J. Figure 1 shows the time evolution of the line averaged electron density, the toroidal current, the plasma stored energy and the magnetic fluctuation amplitude of m/n=4/2 mode in the typical discharge that the MHD instability appears. Here, the discharge is initiated by ECH, from t=185ms the NB are injected, from t=185ms to t=285ms, the injected power is constant. In this discharge, we chose the magnetic configuration that the rotational transform is a little below 0.5 in the whole plasma region (so-called ι~0.49 configuration) because the low-n MHD activities easily occur. There, the change of the rotational transform due the plasma current induces the MHD instabilities. The density increases from starting phase to t~260ms due to the gas-puffing, the plasma stored energy increases with the increase of the density and the plasma current increases due the tangentially injected NB. In the hatched region around t~250ms, the amplitude of magnetic fluctuation with m/n=4/2 structure becomes large, which means the low-n MHD instability occurs. At the same time, the increase of the plasma stored energy looks limited. In order to make clear the change of the confinement property, the stored energy is plotted as the function of the electron density as shown in Fig.2. In Fig.2, the closed circles corresponds to the time when the coherent MHD activity with m/n=4/2 mode appears. When the coherent MHD activity occurs, it was found that the confinement performance is reduced because the scaling of W_p on n_e changes from 1.96 to 0.77 as the power low. It should be noted that the injected power into plasma is almost constant when the density is larger than $0.6\text{x}10^{19}\text{m}^{-3}$ as shown in Fig.1. In order to make the change of the confinement performance more clear, the $W_p/n_e^{1.06}$ is plotted with magnetic fluctuation amplitude as shown in Fig.3. Here the $W_p/n_e^{1.06}$ is normalized as that that just before the occurrence of MHD activity is unity. From Fig.3, the confinement performance is reduced by more than 10% due the low-n MHD instability. It should be that according to the ISS04 empirical scaling, W_p should scale to $n_e^{0.5}$, which is different from the results in this discharge. To resolve the reason of the difference is a future subject.

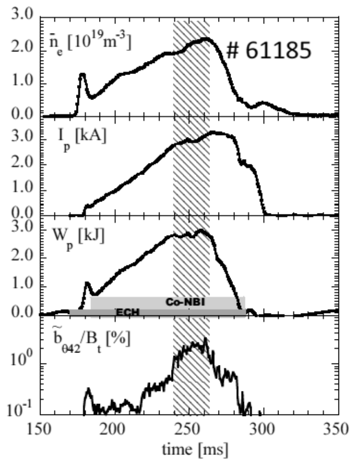

Fig.1 Time evolution of plasma parameters in a typical discharge that MHD instability appears.

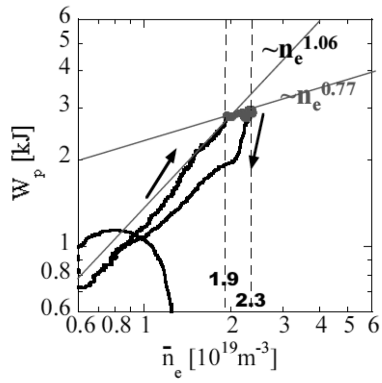

Fig.2 The stored energy as the function of the electron density. ● corresponds to time while MHD instability appears.

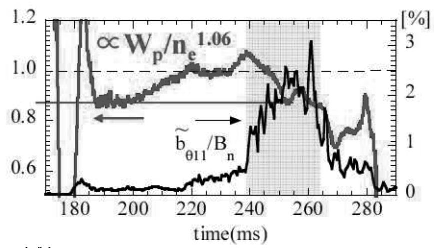

Fig.3 $W_p/n_e^{1.06}$ is plotted with magnetic fluctuation amplitude.

[1] K.Y.Watanabe et al., Phy. Plasma 18, 056119 (2011).