

§50. Evaluation of MHD Stability of Weak Shear Configuration in LHD Plasma

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The sustainment of the high beta plasma is one of the important issues for the achievement of the nuclear fusion plant in toroidal magnetic confinement devices. The plasma beta is limited by the plasma current and/or pressure driven MHD instabilities. The minor collapse and disruption are occurred by MHD instabilities in tokamak plasmas. In the LHD (one of the typical helical device) experiments, the beta collapse phenomenon has been also observed by MHD instability in the weak shear configuration. This study's purpose is to clarify the threshold of the beta limit by the evaluation of the Mercier parameter D_I .

In this study, we have calculated the equilibrium of LHD plasmas with the beta collapse by using VMEC code¹⁾. We had already calculated the equilibrium by using the plasma pressure, which is measured by Thomson scattering system, and the rotational transform $i/2\pi$ profile assumed as uniform, parabolic and hollow current density profile. However the estimated D_I had large scatter. So, it was found that the current density profile is important in order to precisely estimate D_I . Therefore, it is used for the calculation of the equilibrium that $i/2\pi$ profile was measured by motional Stark effect (MSE) diagnostic. In order to form the weak shear configuration, the plasma current is necessary in the LHD configuration. The plasma current I_p was generated by unbalanced Neutral Beam (NB) injection. For example, over 100 kA of plasma current was observed by unbalanced NB injection in LHD device²⁾. Figure 1 shows the typical waveform of the discharge with the collapse (#105388). Because a neon gas puff is applied at the discharge of #105388 to increase the ramp-up rate of I_p , the beta collapse is occurred at about $t = 4.36$ sec, $I_p/B_t = 39.2$ kA/T, and $\langle\beta_{\text{dia}}\rangle = 1.03$ %. In Fig. 1, it is found that the amplitude of $m/n = 1/1$ mode is grown greatly by MHD instability and the beta value and electron temperature are decreased slowly before the collapse.

We evaluated D_I of 8 shots in the three periods as shown in Fig. 1. In the initial phase of discharge, $m/n = 1/1$ mode hardly appears. Next a precursor, $m/n = 1/1$ mode, appears, which is called as the precursor phase. Then the amplitude of $m/n = 1/1$ mode increases and rapidly decrease before the collapse, which is called as the before collapse phase, when the mode rotation is stopped. Figure 2 shows the evaluated D_I and electron pressure gradient at the $i/2\pi = 1$ surface. From Fig. 2, it is found that $m/n = 1/1$ mode is stable in the initial phase of discharge and the value of D_I becomes very large in the precursor phase, then D_I decreases. As one of the reason by which D_I values become smaller before the collapse, it is considered that the electron

pressure gradient is decreased by the growth of $m/n = 1/1$ mode at the $i/2\pi = 1$ surface.

In this study, it is observed that the amplitude of $m/n = 1/1$ mode is rapidly increased before the collapse. As the future work, it is necessary that this result is explained in theory.

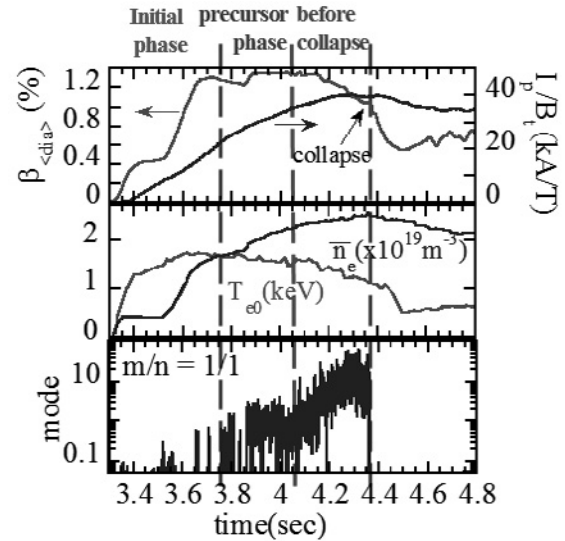


Fig. 1. Temporal evolution of the ratio of plasma current I_p and toroidal magnetic field B_t , volume averaged beta $\langle\beta_{\text{dia}}\rangle$, electron temperature at the plasma center, line averaged electron density, and amplitude of $m/n = 1/1$ mode.

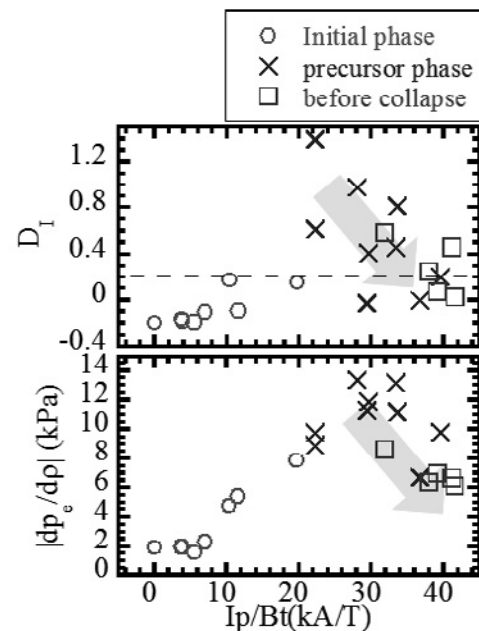


Fig. 2. Mercier parameter D_I and electron pressure gradient versus the ratio of plasma current I_p and toroidal magnetic field B_t ,

- 1) S.P. Hirshman, W.I. Van Rije and P. Merkel, Comput. Phys. Commun. **43** (1986) 143.
- 2) K.Y. Watanabe, et al., Controlled Fusion and Plasma Physics **24B** (2000) 1316.