§16. Beam Pressure Effect on MHD Equilibrium and Stability in LHD

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The high beta experiments in LHD have been performed with the low magnetic field ($\simeq 0.5$ T) and the low density.[1] It is pointed out that the proportion of the beam pressure to the total plasma pressure is large in such experiments. The precise identification of the beam pressure is one of the most important subjects on the equilibrium and stability studies in the high beta helical plasmas. The method to identify the beam pressure with accuracy, however, has been unestablished. Consequently, the purposes of the present study are to establish the high accuracy identification method of the beam pressure and to investigate the effects which the beam pressure has on the equilibrium and stability.

The behavior of the high energy particles in the high beta LHD plasma are analyzed with the use of the real coordinate system. Especially, the re-entering particles,[2,3] which repeatedly go out of and get into the core plasma region, are focused and the effects of these particles to the high beta plasmas are investigated. Particles are traced in the 3 magnetic field configurations (case 1: $B_{\rm ax} = 3$ T, $\langle\beta\rangle = 0.0$ %, case 2: $B_{\rm ax} = 3$ T, $\langle\beta\rangle = 3.2$ % and case 3: $B_{\rm ax} = 0.5$ T, $\langle\beta\rangle = 3.2$ %). The 100 keV protons are traced for a period of 30 ms by numerically solving the guiding-center equation. The particle loss boundary is set at the vacuum vessel wall. The starting points of particles are located at R axis on the horizontally elongated poloidal plane. The initial pitch angels are varied from 0 to π with a step size of $\pi/20$. According to the results, it is found that the particle orbit characteristics are largely-unaltered even if the plasma beta rises. It is also found that the large number of the prompt loss particles exist in the $B_{\rm ax} = 0.5$ T, $\langle\beta\rangle = 3.2$ % case and that such prompt loss particles are promptly lost due to the drift arising from the grad B in the poloidal direction. In addition, it is shown that the number of the re-entering particles increases with increasing the plasma beta (Fig. 1).

With the use of FAR3D code,[4] we analyze the linear resistive MHD in stability modes in the typical high beta LHD plasmas. It has been started to create the database of the growth rate and the structure of the linear resistive MHD in stability modes. The mode structure ($n = 1$, $\langle\beta\rangle = 5.6$ %, $S = 10^4$) is shown in Fig. 2. The calculation with changing β, S and n have been done currently.

The non-linear MHD code with the use of Constrained Interpolated Profile (CIP) method have been developed.[5] After completion of this code, the equilibrium of the LHD will be studied. We will also study the nonlinear stability/instability in the LHD.

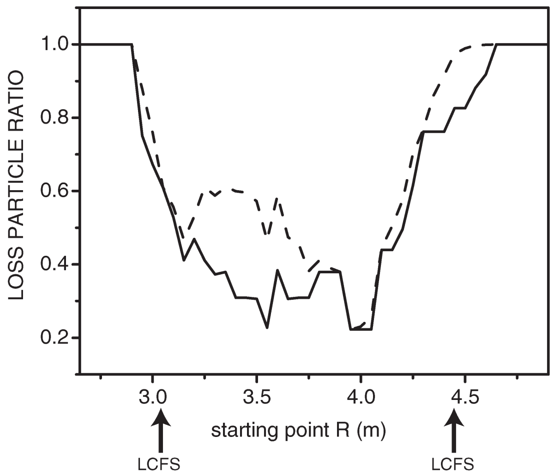

Figure 1: Loss particle ratio of particles in case 3. Values at each starting points are averaged over the pitch angle.

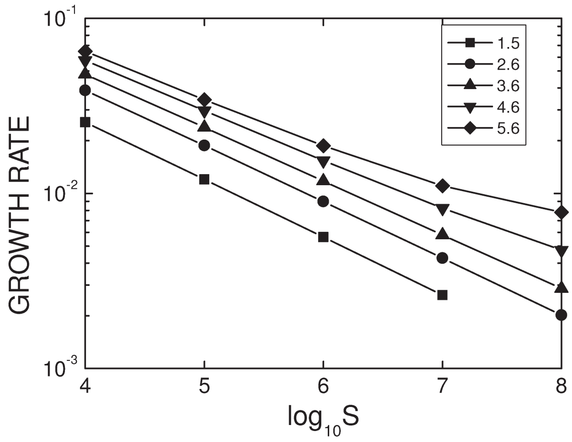

Figure 2: Growth rate of the resistive modes ($n = 1$).

Reference

1) Watanabe, K., *et al.*, 2004 EX3-3 20th Fusion Energy (Vilamoura, 2004).

2) Hanatani, K. and Penningsfeld, F., Nucl. Fusion **32**, 1769 (1992).

3) Charlton, L. A., *et al.*, J. Compt. Phys., **63**, 107 (1986).

4) Matsumoto, Y., J. Plasma Phys., **72**, 1163 (2006).