§34. Ideal MHD Stability Analysis of IDB Plasmas in LHD

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The characteristics of magnetohydrodynamics (MHD) stabilities of plasmas with the internal diffusion barrier[1] (IDB) are intensively studied in the Large Helical Device (LHD) experiment. These plasmas are realized by means of the rapid fueling into the core region with pellet injection. As a result, a steep pressure gradient appears within the core region and the gentle gradient exists in the peripheral region. Figure 1 shows the relationship between central beta β_0 and averaged beta $\langle\beta\rangle$ within the time range from maximum electron density to maximum β_0. In each configuration, the maximum β_0 is achieved in the decreasing-$\langle\beta\rangle$ phase. The peakedness ($\beta_0/\langle\beta\rangle$) increases with R_{ax} and the super dense core (SDC) plasma can be obtained in the configuration of R_{ax} = 3.85[m]. Since the steep pressure gradient is rearized around a core region where the rational surface of $\iota/2\pi = 0.5$ is located, we paid attantion to the global mode of m/n = 2/1 mode (here, m/n means poloidal/toroidal Fourier mode number) and local mode at $\iota/2\pi = 0.5$ surface. Figure 2 shows the relationship between the $d\beta/d\rho$ (pressure gradient at $\iota/2\pi = 0.5$ surface) and the β_0 of experimental data. In configurations with R_{ax} = 3.6[m] and 3.7[m] (Fig.2 (a)(b)), the Mercier stable region (in the lower right region of each figures) expands with R_{ax} and the $d\beta/d\rho$ reaches to 5[%] (Fig.1 (b)). From the result of the 3-D ideal MHD analysis[2], the global mode with m/n = 2/1 appears only in the configuration of R_{ax} = 3.6[m] around β_0~ 2[%] and $d\beta/d\rho$ ~ 1.5[%], whose growth rate (γ/ω_A) and the normalized FWHM of mode width (δ/a) are $\gamma/\omega_A = 1\sim1.5\times10^{-2}$ and δ/a = 0.1, respectively. In case of R_{ax} = 3.7[m], there seems to be the experimental data along the line of D_I = 0 as shown in Fig.2 (b). On the other hand, there are no Mercier unstable region in configurations with R_{ax} = 3.85[m] (Fig.2 (c)). The pressure gradient at $d\iota/d\rho < 0$ is indicated by square symbol in which the rational surface of $\iota/2\pi = 0.5$ locates in the magnetic well region. The pressure gradient increases with β_0 without restriction and the $d\beta/d\rho$ attains to 12[%]. These results are corroborative data that the pressure gradient seems to be suppressed by the ideal local mode in the inward shifted configuration whereas the pressure gradient can be increased in the outward shifted configuration.

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2) W.A. Cooper Plas. Phys. Control. Fusion **34**, (1992) 1011

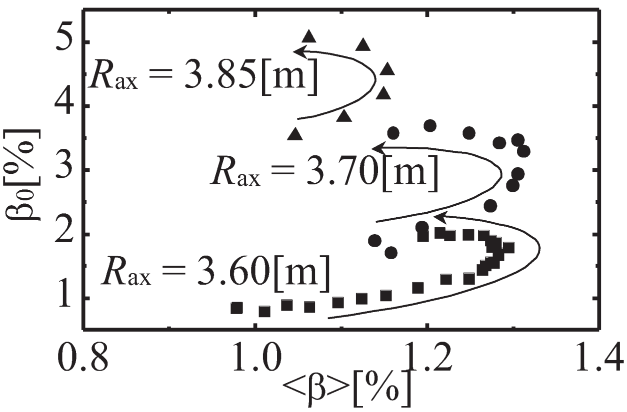

Fig.1. Relationship between central beta β_0 and averaged beta $\langle\beta\rangle$. Symbols of square (R_{ax} = 3.6[m]), circle (R_{ax} = 3.7 [m]) and triangle (R_{ax} = 3.85[m]) show time evolution reaching maximum β_0 from maximum electron density.

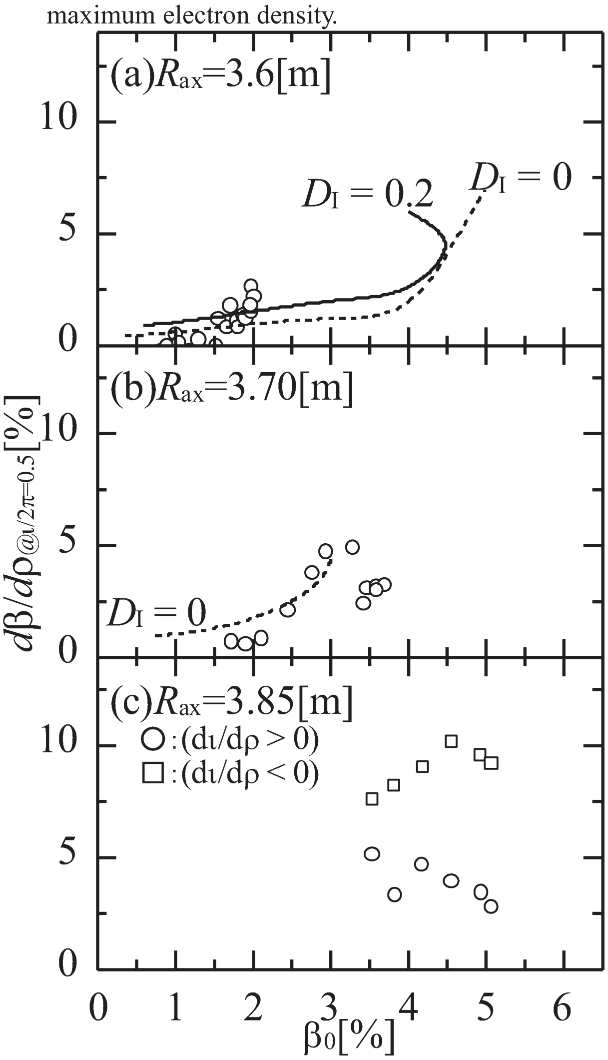

Fig.2. β_0 vs. $d\beta/d\rho$ space at magnetic axis positions of (a) 3.6[m], (b) 3.75[m] and (c) 3.85[m], respectively. Mercier index of D_I = 0 and 0.2 are shown by solid and dashed line, respectively. Symbols of circle (at $d\iota/d\rho > 0$) and square (at $d\iota/d\rho$ < 0) indicate experimental data.