§9. Study of MHD Equilibrium and Stability for Heliotron/Torsatron with Helical Axis

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We have studied the MHD equilibrium and ideal MHD stability for helical axis configuration (HAC) of heliotron/torsatron and compared the results with those of plane circular axis configuration (CAC)[1]. Helical axis configuration can be generated in heliotron/torsatron devices by changing the current ratio of two helical coils. LHD is chosen as the model for studying the equilibrium and stability, because the unbalance between two helical coil currents is possible.

For the vacuum case, the relative depth of magnetic well decreases and rotational transform increases by introducing the helical axis effect. When the current ratio I_2/I_1 is changed to be less than 50%, the helical axis excursion increases substantially as shown in Fig.1. However, the average radius of the outermost magnetic surfaces decreases for $I_2/I_1 < 50\%$ as shown in Fig.2. It is difficult to obtain HAC with magnetic well at zero beta in LHD as well as ATF[2]. However, the rotational transform of HAC is increased uniformly over the whole radius compared to that of CAC. Therefore, HAC may be useful to control the position of low order rational surface.

For the finite beta case, it is noted that the magnetic well depth of HAC is larger than that of CAC, since the helical axis shift is additional and the ordinary Shafranov shift becomes large by the reduction of average plasma radius. The beta limit of HAC by Mercier criterion is slightly smaller than that of CAC. For high beta plasmas, Mercier unstable region is reduced by the helical axis effect. It is clarified that the dominant contribution to the stability comes from the reduction of average plasma radius in HAC. The decrease of Mercier unstable region coincides with the stability of global ideal MHD modes. In the HAC case the beta value to enter the second stability of global interchange modes decreases substantially. It is also confirmed that the main contribution to this change comes from the reduction of average plasma radius in HAC.

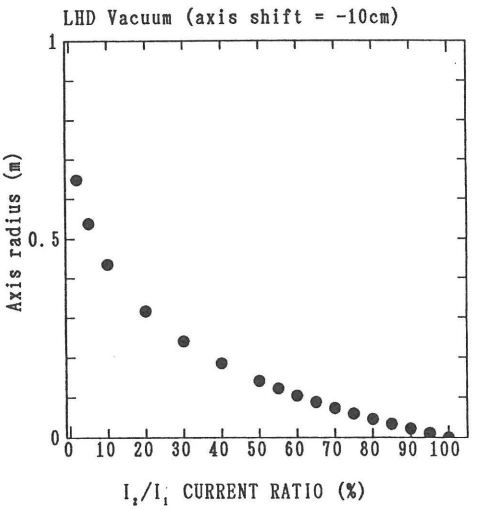

Fig.1. Variation of helical axis radius, r_{axis}, as a function of current ratio of two helical coils, I_2/I_1 for vacuum configuration of LHD.

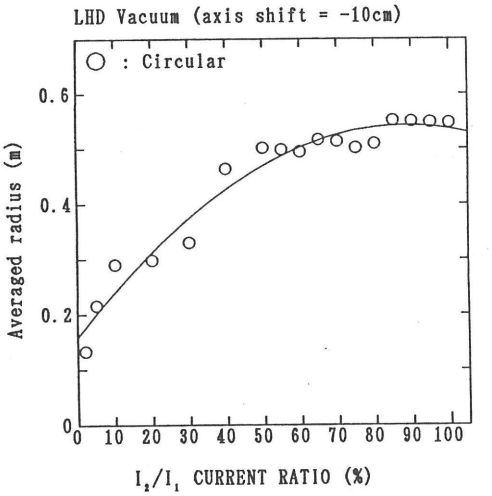

Fig.2. Variation of average plasma radius, a, as a function of current ratio of two helical coils, I_2/I_1 for vacuum configuration of LHD.

References

1) Matsumoto, T., Nakamura, Y., and Wakatani, M., J. Phys. Soc. Jpn 64 (1995) 4175.

2) Hender, T. C. and Carreras, B. A., Phys. Fluids 27 (1984) 2101.