§20. Improved Stability due to Local Pressure Flattening in Stellarators

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The stability improvement for the low n pressure gradient driven modes was investigated in stellarators by local flattening of the pressure gradient at the resonant surfaces.[1] Three-dimensional equilibria with such pressure profile were calculated with the VMEC code. For describing the locally flattened pressure profile,

$$P(\rho) = C[P_o(\rho) + P_{ax}(\rho) + P_{res}(\rho) - A]. \quad (1)$$

was assumed, where ρ means the square root of the normalized toroidal flux. Here, $P_o(\rho)$ denotes the standard smooth profile, $P_{ax}(\rho)$ corresponds to a flattening of the pressure profile near the magnetic axis given by

$$P_{ax}(\rho) = [P_o(0) - P_o(\rho)] \exp\left[-\frac{1}{2}\left(\frac{\rho}{w_a}\right)^4\right], \quad (2)$$

and $P_{res}(\rho)$ plays a role in flattening the pressure at rational surfaces expressed by

$$P_{res}(\rho) = \sum_m \{[P_o(\rho_m) + P_{ax}(\rho_m)] - [P_o(\rho) + P_{ax}(\rho)]\} \times \exp\left[-\frac{1}{2}\left(\frac{\rho - \rho_m}{w_m}\right)^4\right]. \quad (3)$$

A and C in eq.(1) are numerical factors to fix the pressure at both the magnetic axis and the plasma surface. In eq.(2), w_a denotes the width of the region of the flat pressure profile near the magnetic axis. In eq.(3), ρ_m means the position of the m-the rational surface and w_m denotes the width of the flat pressure region at $\rho = \rho_m$. The low n ideal stability of the equilibrium with the locally flattened pressure profile was examined by the RESORM code, which is based on the reduced MHD equations.

We examined the LHD equilibrium with an inward magnetic axis shift of 25cm and chose the profile of $P_o \propto (1 - \rho^2)^2$. Figure 1 shows the profile of P_o at the horizontally elongated cross section. At $\beta_0 = 2\%$, the equilibrium is unstable against the low n interchange mode. We tried to stabilize the ideal modes with $n =$ 1, 2 and 3 by flattening the pressure locally with the expression of (1), and we obtained the profile in which the modes are stable simultaneously. Figure 2 shows the marginally stable pressure profile against the low n modes. When the beta value is increased, these modes may not be able to stabilized completely even with the local flattening of the pressure. Therefore, this method gives a new concept in the determination of the critical beta limit against the pressure driven mode.

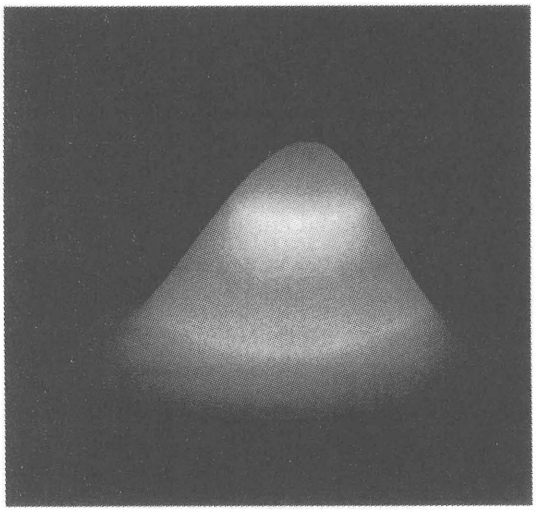

Fig.1 Profiles of the smooth pressure.

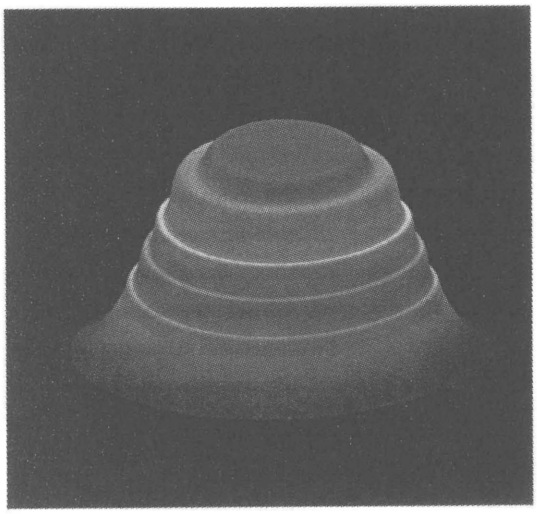

Fig.2 Profiles of the locally flattened pressure.

References

1) Ichiguchi, K., et al., Nucl.Fusion 41 (2001) 181.