§31. Role of Bumpy Field for Improvement of Collisionless Particle Confinement in Helical Axis Heliotrons

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The planned experimental device for plasma confinement research in Kyoto University is based on the helical axis heliotron concept [1] with controllable bumpy field. The bumpy field has been negligibly small in conventional heliotrons, and therefore, it is essential to grasp its roles to develop the helical axis heliotron concept.

As the first step to study the collisionless particle confinement, the structure of B_{min} contours, which is frequently utilized to measure the collisionless particle confinement properties in the Large Helical Device (LHD) [2], has been considered by the model magnetic field including the bumpy field as:

$$\begin{aligned} B &= B_{00}\{(f+(1-f)(r/a)^2) \\ &- \epsilon_{ha}(r/a)\cos(\theta_B - M\zeta_B) \\ &- \epsilon_{ta}(r/a)\cos\theta_B \\ &- \epsilon_b(1+\Delta_b(r/a)^2)\cos M\zeta_B\}. \end{aligned}$$

Here $\theta_B(\zeta_B)$ is the poloidal (toroidal) angle in the Boozer coordinates, r/a the normalized average radius, M the number of the field period, f models the diamagnetic effect and the vacuum magnetic well/hill, and Δ_b measures the increase of the bumpy field towards the plasma edge. Figure 1 shows the fraction of closed B_{min} area to that of average poloidal cross section of plasma boundary as a function of ϵ_b/ϵ_{ha} for different $\epsilon_{ta}/\epsilon_{ha}$ (white lozenge, black lozenge, white square and black square for $\epsilon_{ta}/\epsilon_{ha} = 0.0, 0.25, 0.50$ and 0.75 cases) and B_{min}/B_{00} values (0.80, 0.85, 0.90, 0.95 from top to bottom) with $f = 1$ and $\Delta_b = 0$. Each line extends from maximum to minimum values of ϵ_b/ϵ_{ha} to close the corresponding B_{min} contour. It clearly demonstrates that there is an appropriate range of bumpy field for closing B_{min} contours, and also the negative ϵ_b/ϵ_{ha} is desirable for larger $\epsilon_{ta}/\epsilon_{ha}$ cases. This fraction of closed B_{min} area strongly correlates to the collisionless particle confinement efficiency from the results of particle orbit following in the Boozer coordinates. The effects of f and Δ_b relate to the formation of the global magnetic well (for $f \lesssim 1$) and localized magnetic well (for $\Delta_b \neq 0$), whose effects on the collisionless particle confinement are now under investigation. The realization of the appropriate magnetic field spectra for a good collisionless particle confinement with the planned coil system will also be pursued based on this study.

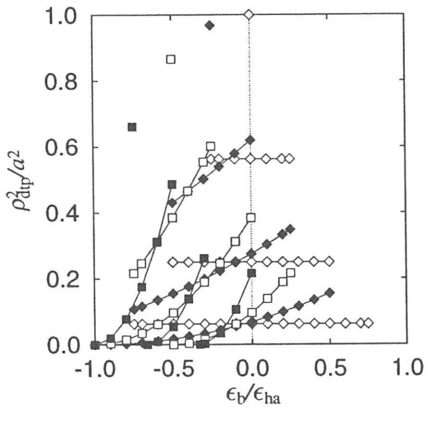

Fig. 1. Fraction of closed B_{min} area for different $\epsilon_{ta}/\epsilon_{ha}$ and B_{min}/B_{00} cases.

References
[1] YOKOYAMA, M., NAKAMURA, Y., WAKATANI, M., to appear in J. Plasma and Fusion Res. **7**(1997).
[2] IIYOSHI, A., et al., Fusion Technol. **17**(1990)169.