§18. Theoretical study and Experimental Verification on the Effects of Magnetic Configuration on the Improved Confinement Mode in Heliotron J

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The improved confinement mode has been observed in Heliotron J, for which the existence of rational surfaces at the plasma periphery seems to play important role. The effects of the corrugation of peripheral magnetic surface shape on the poloidal viscosity have been investigated based on the equilibrium information on the Hamada coordinates. Further corrugation is expected (based on the field line tracing calculations) beyond the VMEC-treatable last-closed-flux surface, and the effects of such further corrugation has been one of the key targets to be clarified. The formation of Boozer coordinates based on field line tracing approach (at vacuum condition) has been successfully performed for this purpose.

The formation of Boozer coordinates at the finite β condition, of course, is also important subject when the application to the experimental results is considered. The interface to the HINT2 code, in which the nested-magnetic-surface approximation is not required, was developed, and then, Boozer coordinates formation with high-accuracy has become available even for the MHD equilibria with magnetic island inside the confinement region. The "effective nested magnetic surfaces" are formed inside the magnetic island region in this approach. In the following, this approach is explained by showing examples.

Figure 1(a) shows the finite β (1% on the magnetic axis) MHD equilibrium in Heliotron J. The 4/7 island appears at about the mid-radius. The magnetic island region, as like the magnetic axis, is singular on the magnetic coordinate system, and it is impossible to construct the Boozer coordinates if magnetic islands appear in the confinement region. However, as shown in Fig. 1(b), by considering the existence of "effective nested magnetic surfaces", Boozer coordinates can be successfully constructed. Figure 2 shows magnetic field spectrum in the constructed Boozer coordinates. It is, of course, important to remind that the equilibrium quantities evaluated in the magnetic island region is physically meaningless. But, this approach can provide the capability of Boozer coordinates construction in a wide range of equilibria. Theoretical evaluation of such as effective helicity, interrelationship between plasma viscosity and plasma flow, will be performed for a wide range of Heliotron J, to increase the physics understanding of the improved confinement in Heliotron J.

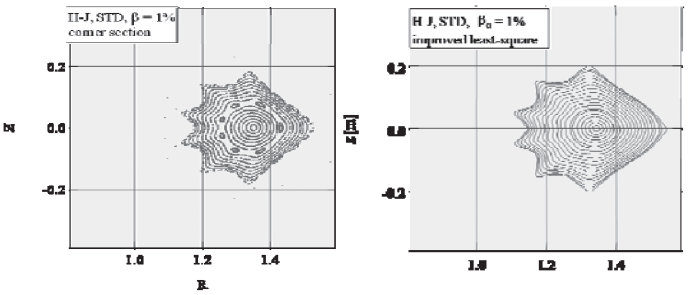

Fig. 1 Finite β equilibrium in standard configuration of Heliotron J. (a) 4/7 island appears. (b) "Effective nested magnetic surfaces" are assumed at the magnetic island region.

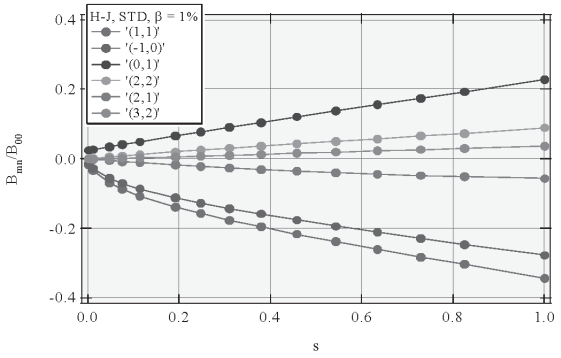

Fig. 2 Magnetic field spectrum in Boozer coordinates, obtained based on equilibrium shown in Fig. 1(b).