Properties of ballooning modes in the Heliotron configurations

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The stability of ballooning modes is influenced by the local and global magnetic shear and local and global magnetic curvature so significantly that it is fairly difficult to get those general properties in the three dimensional configurations with strong flexibility due to the external coil system. In the case of the planar axis heliotron configurations allowing a large Shafranov shift, like LHD [1], properties of the high-mode-number ballooning modes have been intensively investigated.

It has been analytically shown that the local magnetic shear comes to disappear in the stellarator-like global magnetic shear region, as the Shafranov shift becomes large [2]. Based on this mechanism and the characteristics of the local and global magnetic curvature, it is numerically shown that the destabilized ballooning modes have strong three-dimensional properties (both poloidal and toroidal mode couplings) in the Mercier stable region, and that those are fairly similar to ballooning modes in the axisymmetric system in the Mercier unstable region [3]. As is well known, however, no quantization condition is applicable to the ballooning modes in the three-dimensional system without symmetry, and so the results of the high-mode-number ballooning modes in the covering space had to be confirmed in the real space. Such a confirmation has been done in the Mercier stable region [4] and also in the Mercier unstable region [5] by using three dimensional linearized ideal MHD stability code cas3d [6].

Confirming the relation between high-mode-number ballooning analyses by the global mode analyses, the method of the equilibrium profile variations has been developed in the tree dimensional system, giving $d\iota/d\psi - dP/d\psi$ stability diagram corresponding to the $s - \alpha$ diagram in tokamaks [7]. This method of profile variation are very powerful to investigate the second stability of high-mode-number ballooning modes and has been more developed [8]. Recently it has been applied to the plasma in the inward-shifted LHD configuration [9], where it has been shown that the plasma core region stays in the second stability region of the high-mode-number ballooning modes, and that the peripheral region is near the marginal stable.

In this work, the ballooning researches in the planar axis heliotron configurations will be summarized systematically, and recent research related to the ballooning modes like the second stability and so on in the inward-shifted LHD configurations will be extended.

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