§2. Global Mode Analysis of Ideal MHD Modes in a Heliotron/Torsatron System: I. Mercier-unstable Equilibria

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By means of a global mode analysis of ideal MHD modes for Mercier-unstable equilibria in a planar axis $L = 2/M = 10$ heliotron/torsatron system with an inherently large Shafranov shift, the conjecture from local mode analysis for Mercier-unstable equilibria given in Ref.[1] has been confirmed and the properties of pressure-driven modes, namely, ballooning modes and interchange modes, inherent to such three-dimensional systems have been clarified.[2]

The change of the local magnetic shear due to the Shafranov shift, which is related to toroidicity, reduces the field line bending stabilizing effects on ballooning modes. According to the degree of the reduction of the local magnetic shear by the Shafranov shift, the Mercier-unstable equilibria are categorized into toroidicity-dominant (strong reduction) and helicity-dominant (weak reduction) Mercier-unstable equilibria, so that ballooning modes are easier destabilized in the toroidicity-dominant Mercier-unstable equilibria than helicity-dominant Mercier-unstable equilibria.

Since the local magnetic curvature due to helicity has the same period M in the toroidal direction as the toroidal field period of the equilibria, the characteristics of the pressure-driven modes in such Mercier-unstable equilibria dramatically change, both according to the reduction of the local magnetic shear by the Shafranov shift and also according to the relative magnitude of the typical toroidal mode number n of the perturbation compared with the toroidal field period of the equilibria M.

In the toroidicity-dominant Mercier-unstable equilibria, the pressure-driven modes change from interchange modes for low toroidal mode numbers $n < M$, to tokamak-like poloidally localized ballooning modes with a weak toroidal mode coupling for moderate toroidal mode numbers $n \sim M$, and finally to both poloidally and toroidally localized ballooning modes purely inherent to three-dimensional systems for fairly high toroidal mode numbers $n \gg M$.

In the helicity-dominant Mercier-unstable equilibria, the pressure-driven modes change from interchange modes for $n < M$ or $n \sim M$, directly to both poloidally and toroidally localized ballooning modes purely inherent to three-dimensional systems for $n \gg M$. Those interchange modes are localized on the inner side of the torus, because the Shafranov shift enhances the unfavorable magnetic curvature there rather than on the outer side of the torus.

In both types of Mercier-unstable equilibria, the pressure driven modes become more unstable and more localized both on flux tubes and in the radial direction, and have stronger toroidal mode coupling through the magnetic curvature due to helicity, as the typical toroidal mode numbers increase. All of these properties are consistent with the conjecture from the local mode analysis.

One of typical ballooning modes inherent to three-dimensional system is shown in Fig.1.

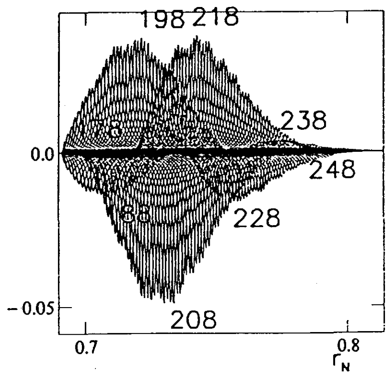

Fig.1 Radial distribution of the Fourier components of the normal displacement $\vec{\xi} \cdot \nabla\psi$ with their dominant toroidal mode numbers

References

[1] N. Nakajima, Phys. Plasmas **3** (1996) 4556.
[2] J. Cheg, N. Nakajima, and M. Okamoto, Phys. Plasmas (in press).