§ 30. Comparative Study of Ideal MHD Stability for CHS-qa and CHS

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Ideal MHD stability analysis is essential to physics design of a new device for exploring achievable beta limit. In the case of QA stellarator, ideal MHD stability properties are possibly in contrast to those of conventional devices because of characteristic differences in magnetic well and shear. In this work we have carried out comparative study of ideal MHD stability for Compact Helical System (CHS) and a proposed compact QA stellarator CHS-qa.

Firstly, we have analyzed local ballooning mode and Mercier criterion based on fixed boundary currentless VMEC equilibria of standard configurations by using KSP and COBRA[1] codes. Assumed pressure profile has the form of $p_0(1-s)^{1.5}$ which is reasonably achievable in experiments. The results are summarized in Fig. 1 where unstable regions of Mercier criterion and local ballooning mode are indicated by cross and diamond symbols, respectively, on two dimensional space of flux surface label and average beta. Since the magnetic axis of the CHS standard configuration is shifted inward from the major radius position, it is reasonably unstable for Mercier criterion even in low beta equilibria as shown in Fig. 1. In contrast, CHS-qa standard configuration is kept stable against Mercier criterion up to the maximum average beta studied. Contributions of each terms in Mercier criterion indicate that magnetic well and shear terms compete for determining stability in CHS, while magnetic well and geodesic curvature terms in CHS-qa. Though it looks unusual that unstable region for local ballooning mode is smaller than that for Mercier criterion in Fig. 1 (a), it may be because ballooning mode calculation is terminated at finite length of a field line, which should be improved in the future.

We have also carried out global mode analysis using TERPSICHORE[2] code in order to assess experimentally practical beta limit. Perturbation modes up to $m = 36$ and $n = 11$ including fundamental mode coupling are considered, and conducting wall is located far enough from the plasma boundary to avoid wall stabilizing effects in the calculation. Figure 2 shows eigenvalues λ for the most unstable $N = 1$ family mode as functions of average beta. Positive $-\lambda$ (negative eigenvalue) means instability. Beta limit is at least higher than 3.5% in the currentless case of CHS-qa, while much lower in CHS standard configuration even though no deterioration of confinement has been observed up to an average beta of 2 % in CHS experiments. The eigenfunctions of unstable modes in CHS exhibit nature of ballooning mode.

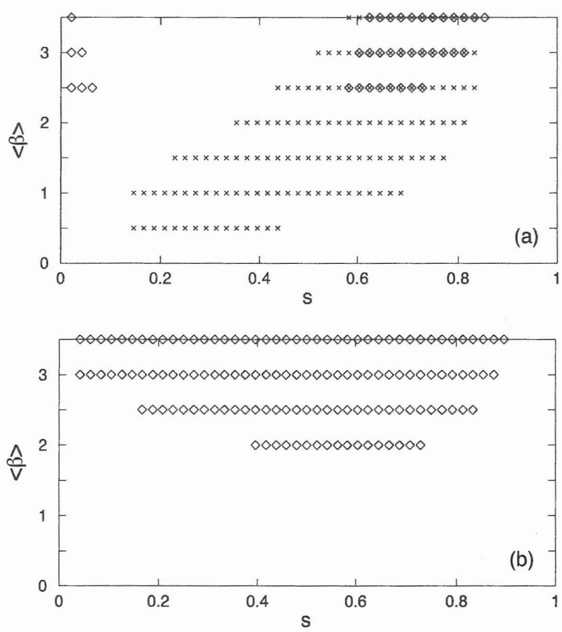

Fig. 1. Unstable regions for Mercier criterion (crosses) and local ballooning mode (diamonds) on two dimensional space of flux surface label and average beta for (a) CHS and (b) CHS-qa standard configurations.

References

1) Sanchez, R. et al.: J. Comput. Phys. **161** (2000) 576.

2) Anderson, D. V. et al.: Int. J. Supercompt. Appl. **4** (1990) 34.

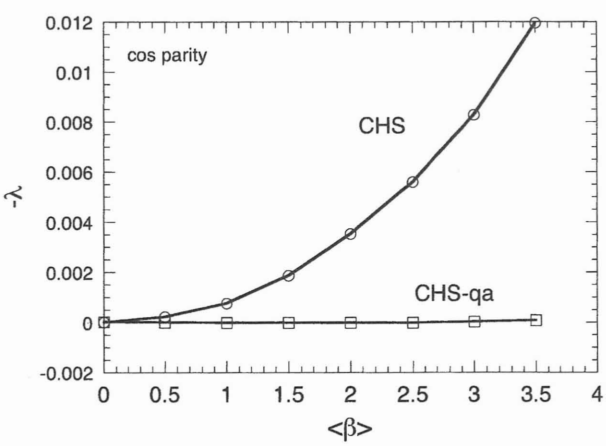

Fig. 2. Eigenvalues of the most unstable N=1 family mode for standard configurations of CHS and CHS-qa calculated by Terpsichore code.