4th Asia-Pacific Conference on Plasma Physics, 26-31Oct, 2020, Remote e-conference

Prediction of linear stability of Multi-Region relaxed MHD energy principle

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Multi Region relaxed Magnetohydrodynamics (MRxMHD) is a variational principle, which postulates the generalization of Taylor's relaxation theory of global magnetic energy subject to additional topological constraints. Plasma is partitioned into N number of nested volumes separated by ideal interfaces that are assumed to remain as magnetic flux surfaces during the minimization processes. In each volume, the plasma undergoes Taylor relaxation and the magnetic helicity, is conserved within the volume, along with the toroidal and poloidal magnetic fluxes. The Stepped-Pressure Equilibrium code (SPEC) [1], has been developed to study MRxMHD equilibrium fields. However, SPEC can also exploit, to predict MHD instabilities with second variation of its energy functional so-called Hessian. We demonstrate, newly implemented Hessian algorithm in SPEC which can predict linear MRxMHD stability of plasma equilibria. Negative eigenvalues of Hessian indicate instability. As a validation, we have compared a marginal stability calculation of SPEC with an Ideal MHD tokamak stability code MISKHA-1 for a current and pressure driven (m,n)=(1,1) internal kink instability. In order to describe an ideal MHD stability theory efficiently with SPEC we pack large number of nested interfaces within plasma volume. We observe that marginal stability boundaries of SPEC are in well agreement with MISKHA-1 as shown in Figure 1. We will also discuss, our study of low shear ballooning modes with SPEC hessian as to analyze the role of critical pressure gradients in stepped pressure equilibria. This will open a new pathway to investigate MHD stability studies in 3D stellarator geometry.

References

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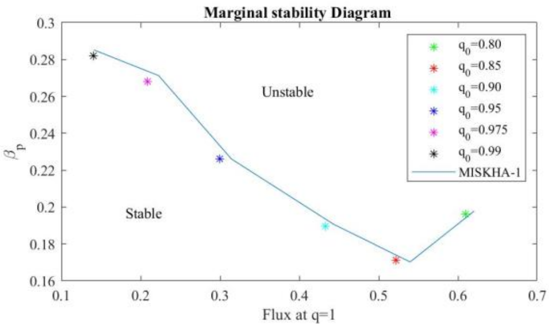

Figure 1. Marginal stability as a function of poloidal Bussac beta β_p[2] of SPEC (colored Asterix) and MISKHA-1 (dashed line) versus normalized flux at q=1 rational surface for a different central value of safety factor q_0.