Control of Non-Axisymmetric Fields With Static and Dynamic Boundary Conditions*

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Small deformations of the otherwise axisymmetric field, known as “error fields” (EFs), lead to large changes in global MHD stability. This talk will compare results from both 1) a line-tied screw-pinch with rotating conducting walls and 2) the DIII-D tokamak to illustrate that in both devices the EF has greatest effect where it overlaps with the spatial structure of its global kink mode. In both configurations the kink structure in the symmetry direction is well described by a single mode number (azimuthal m=1, toroidal n=1, respectively) and EF ordering is clear. In the asymmetric direction (axial and poloidal, respectively) the harmonics of the kink are coupled (by line-tying and toroidicity, respectively) and thus EF ordering is not straightforward. In the pinch, the kink is axially localized to the anode region and consequently the anode EF dominates the MHD stability. In DIII-D, the poloidal harmonics of the n=1 EF whose pitch is smaller than the local field-line pitch are empirically shown to be dominant across a wide breadth of EF optimization experiments. In analogy with the pinch, these harmonics are also where overlap with the kink is greatest and thus where the largest plasma kink response is found. The robustness of the kink structure further enables vacuum-field cost-function minimization techniques to accurately predict optimal EF correction coil currents by strongly weighting the kink-like poloidal harmonics in the minimization. To test the limits of this paradigm recent experiments in DIII-D imposed field structures that lack kink-overlapping harmonics, yielding ≈10X less sensitivity. The very different plasmas of the pinch and tokamak thus both demonstrate the dominance of the kink mode in determining optimal EF correction.

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