Plasma response models for non-axisymmetric perturbations

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Abstract

The plasma response to non-axisymmetric perturbations arising from external coils or linear instabilities can be treated using various linear and nonlinear models, none of which are fully satisfactory. Linear models cannot provide the full response and the result can depend on the detailed physical model used. The nonlinear response can be treated as a dynamic stability problem or from a nearby perturbed equilibrium approach. The nearby equilibrium approach aims to bypass the detailed evolution and search for the appropriate final state. For these nonlinear models, there is no guarantee that the final state is the one chosen dynamically by the plasma among possible multiple states, or is even accessible. To assure accessibility of the final state, one needs to relate the two-dimensional (2-D) and nearby three-dimensional (3-D) system through some set of invariants. The simplest implementation is to add a perturbation from an external field or obtained from a stability code to the equilibrium and solve for 3-D force balance. In that case, the invariants are buried in the numerical details of the equilibrium code. An appropriate set of constraints is not presently known. However, the constraints can be informed from linear and full nonlinear calculations. They also depend on whether the dynamic evolution should be considered adiabatic or not. A suitable set of invariants may be obtained from considering the magnetic helicity, which is conserved exactly in ideal MHD but is broken at rational surfaces by non-ideal effects.

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