Approach to nonlinear magnetohydrodynamic simulations in stellarator geometry

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Capabilities to model the nonlinear magnetohydrodynamic (MHD) evolution of stellarator plasmas are developed by extending the M3D-C^1 code from axisymmetric to non-axisymmetric geometry. We introduce a set of logical coordinates, in which the computational domain is axisymmetric, to utilize the existing finite-element framework of M3D-C^1. A C^1 coordinate mapping connects the logical domain to the non-axisymmetric physical domain, where we use the M3D-C^1 extended MHD models essentially without modifications. We present several numerical verifications on the implementation of this approach, including simulations of the heating, destabilization, and equilibration of stellarator plasmas with strongly anisotropic thermal conductivity, and of the relaxation of stellarator equilibria to integrable and non-integrable magnetic field configurations in realistic geometries. Preliminary results from physics studies such as simulations of ECCD-induced sawtooth-like crashes on W7-X will also be presented.

References

[1] Y. Zhou, N. M. Ferraro, S. C. Jardin, and H. R. Strauss, Nucl. Fusion 61, 086015 (2021).

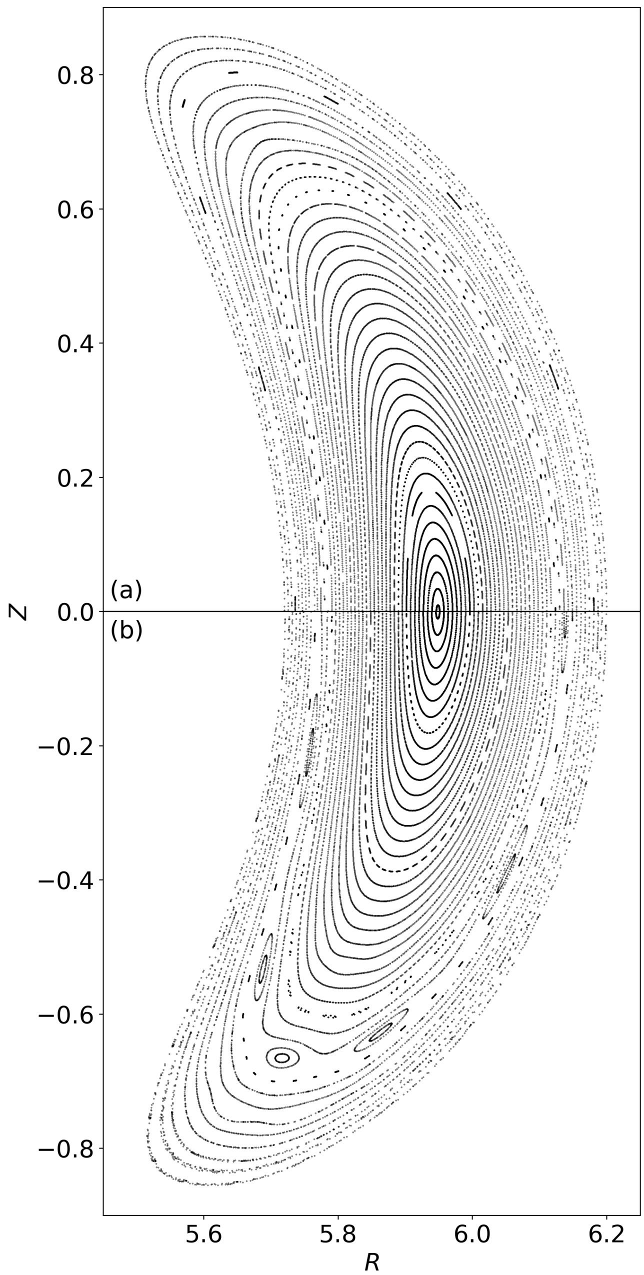

Figure 1. Poincaré plots of (a) the initial magnetic field that is interpolated from a W7-X VMEC equilibrium (normalized by Tesla and meter), and (b) the relaxed magnetic field obtained in M3D-C^1, where the majority of flux surfaces stay intact and barely displaced.