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Self-consistent simulations of nonlinear MHD and profile evolution in stellarator configurations[1]

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Self-consistent MHD equilibrium and nonlinear stability of 3D magnetic configurations are investigated using the extended MHD code NIMROD. In these calculations, initial conditions are given by 3D vacuum solutions with robust magnetic surfaces. We examine two classes of problems: those with current-driven instabilities and those with pressure-driven instabilities. Ohmic discharges in the Compact Toroidal Hybrid (CTH) are simulated [1]. The vacuum magnetic field of CTH is initialized and current is driven by specifying a toroidal electric field at the vessel boundary. The driven current penetrates toward the core and raises the rotational transform profile. Island formation is observed that is linked to the n=5 periodicity of the device. A prominent feature of these simulations is the coalescence of n/m=5/10 islands to n/m=1/2 islands when the rotational transform exceeds 0.5. At high levels of current drive, complete flux surface destruction is observed. Comparison with CTH data will be presented. Finite beta discharges in a straight stellarator are simulated. Vacuum magnetic fields are applied to produce stellarator-like rotational transform profiles with iota(0)$\leq$0.5 and iota(0)$\geq$0.5. The vacuum magnetic fields are either helically symmetric or spoiled by the presence of magnetic harmonics of incommensurate helicity. As heat is added to the system, pressure-driven instabilities are excited when a critical β is exceeded. These instabilities may cause disruption, or they may saturate nonlinearly as the equilibrium evolves. In all of these studies, anisotropic heat conduction is allowed with $k_{par}/k_{perp} = 10^5$–10^7. Due to the finite parallel heat conduction, in some cases an equilibrium state persists that has a stochastic edge region which supports a pressure gradient.

[1] M.G. Schlutt, et al., submitted to Nuclear Fusion (2012).

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