# 3D Modeling of NSTX Vertical Displacement Events with M3D-C1

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Nonlinear free-boundary 3D tokamak resistive wall instabilities are calculated using a new resistive wall model [1] in the two-fluid M3D-C1 3D magnetohydrodynamics code. In this model, the resistive wall and surrounding vacuum region are included within the computational domain. This implementation contrasts with the method typically used in fluid codes in which the resistive wall is treated as a boundary condition on the computational domain boundary using the thin-wall approximation. Besides allowing a finite thickness, and possibly a non-axisymmetric wall, this approach has the advantage of maintaining purely local coupling of mesh elements. This new capability is used to simulate the fully 3D nonlinear evolution of vertical displacement events (VDEs) in NSTX. The VDE calculations are performed in diverted tokamak geometry, at physically realistic values of dissipation, and with resistive walls of finite thickness. When the vertical control system is switched off, the plasma begins to drift, initially axisymmetrically, with a vertical growth rate proportional to the wall resistivity. After a brief period, as the plasma drifts and deforms, a toroidal mode number n=1 resistive wall mode with dominant poloidal mode number m=2 begins to appear, and it too initially grows with a growth rate proportional to the wall resistivity. Eventually, as the plasma becomes limited by the first wall, the growth rate of the n=1 mode increases dramatically leading to a rapid thermal and current quench. Strong (induced) currents are observed to flow in the wall and between the plasma and the wall (halo). New diagnostics are being implemented to facilitate comparisons between these results, previous M3D and TSC simulations, and NSTX magnetics data. These simulations have recently become more efficient as M3D-C1 now has the capability of restarting a 3D calculation from a 2D one, so the axisymmetric phase of the VDE can be done very efficiently in 2D.

[1] Ferraro, N.M., Jardin, S. C., Lao, L.L., Shephard, M., Zhang, F., "Multi-Region Approach to Free-Boundary 3D Tokamak Equilibria and Resistive Wall Instabilities", submitted to J. Comp. Phys. (2015)