Status and plans for VDE modeling with M3D-C^1

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Details on the status of NSTX VDE modeling

Invited talk

The ins and outs of modelling vertical displacement events

David Pfefferlé

Wednesday 9:30–10:00 AM

NI3.00001

Using M3D-C^1 for VDE simulations

- linear VDE growth rate

  linear

  2D nonlinear (linear phase)

  2D nonlinear → linear

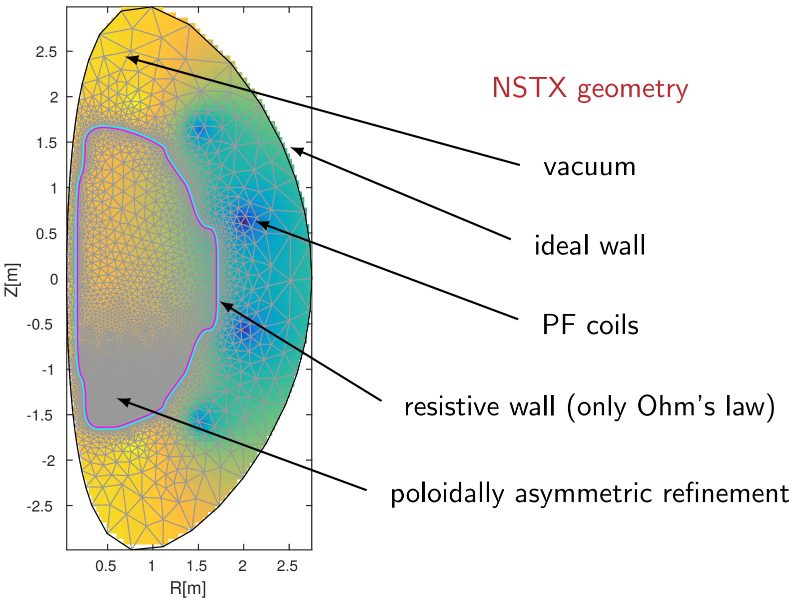
- nonlinear VDE evolution

  2D nonlinear

  2D nonlinear → 3D nonlinear

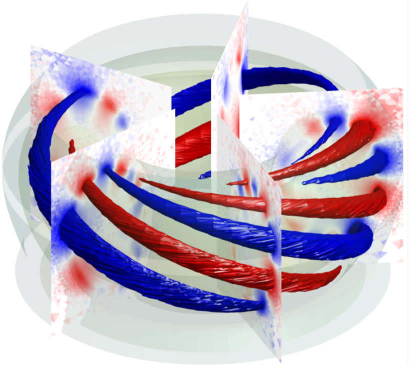
  ↑ linear

Mesh: Plasma, resistive wall & vacuum

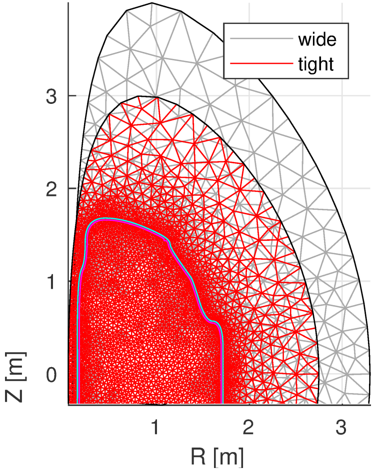


New postprocessing tool: `c1matlab`

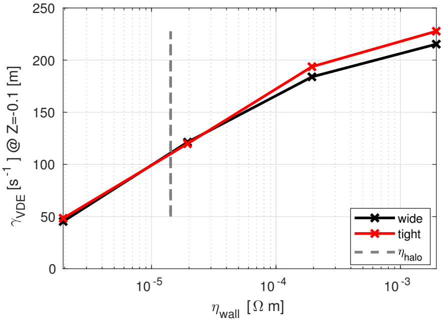
- wall currents & forces, in particular divertor region
- 2D & 3D movies
- ...



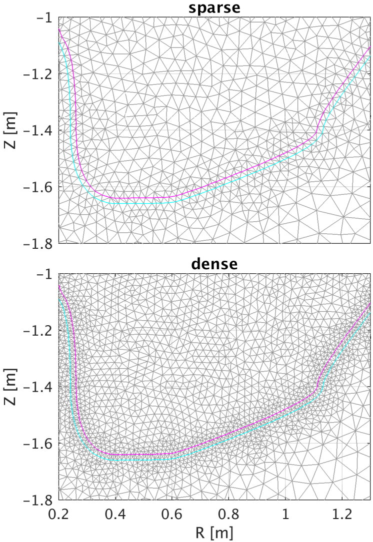
Computational boundary does not affect VDE



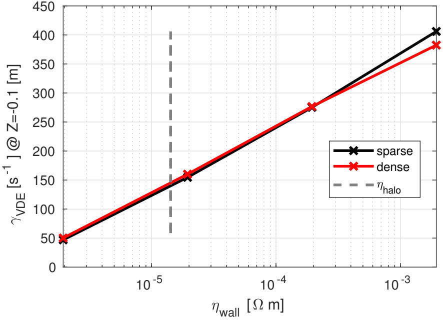
- computational boundary is a perfect conductor
- $<$ 1% effect on nonlinear 2D evolution for highest wall resistivity and fastest VDE



Induced wall currents supported by few mesh points



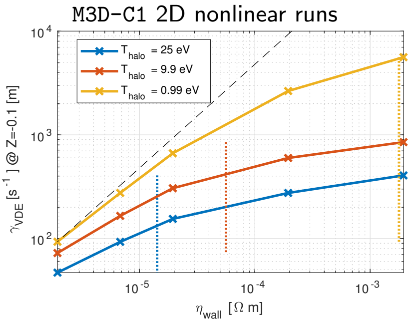
- skin depth
  $\delta = \sqrt{2\eta_w/\gamma_{VDE}\mu_0} \gtrsim 10cm$
- currents are well resolved in resistive wall despite small thickness



Halo temperature has notable impact on VDE evolution

- VDE growth rate
  $\gamma_{\text{VDE}} \propto \eta_{\text{wall}}$ for small η_{wall}
- $T_{\text{halo}} = p_{\text{edge}}/n_{\text{edge}}$ cannot be too small to avoid negative overshoot
  - $T_{halo} = 25eV$ and $\eta_{halo} \approx 1.4 \times 10^{-5}\Omega m$
  - cross-section of open field-line region is large
    - $\Rightarrow$ η_{halo} competes with wall
- Workaround: compute Spitzer resistivity by

$$\eta(\boldsymbol{x}) = \frac{\eta_0}{(T_e(\boldsymbol{x}) - T_{\text{offset}})^{3/2}}$$



VDE benchmark between M3D-C^1 & NIMROD

- 2D nonlinear
- generic tokamak geometry
- simple case which is easy to reproduce with other codes
- rectangular resistive wall?
- starting from vertically unstable equilibrium
- comparison of overall forces on wall
  $\mathbf{F} = \int_{\text{wall}} \mathbf{j} \times \mathbf{B} \, dV$

More plans for M3D-C^1 VDE modeling

- Benchmarking
  - NIMROD (first 2D, later 3D)
  - possibly DINA (2D)
- use DIII-D cases
- enable variable halo width
- develop reduced model that reflects important aspects of 3D nonlinear simulations
- using breaks in resistive wall
- ITER VDE modeling

Long-term

- influence of 3D wall on vessel forces