Hybrid Simulations of N=1 Mode in ITER

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Outline

- M3D code: hybrid model
- Review of recent results
- Work in progress

Particle closure for energetic particles and thermal ions

$$\rho\frac{d\mathbf{v}}{dt}+\rho(\mathbf{v}_\mathbf{i}^\star\cdot\nabla)\mathbf{v}_\perp=-\nabla P-\nabla\cdot\mathbf{P}_h+\mathbf{J}\times\mathbf{B}-\mathbf{bb}\cdot\nabla\cdot\Pi_i$$

$$\mathbf{J}=\nabla\times\mathbf{B},\qquad\frac{\partial\mathbf{B}}{\partial t}=-\nabla\times\mathbf{E}$$

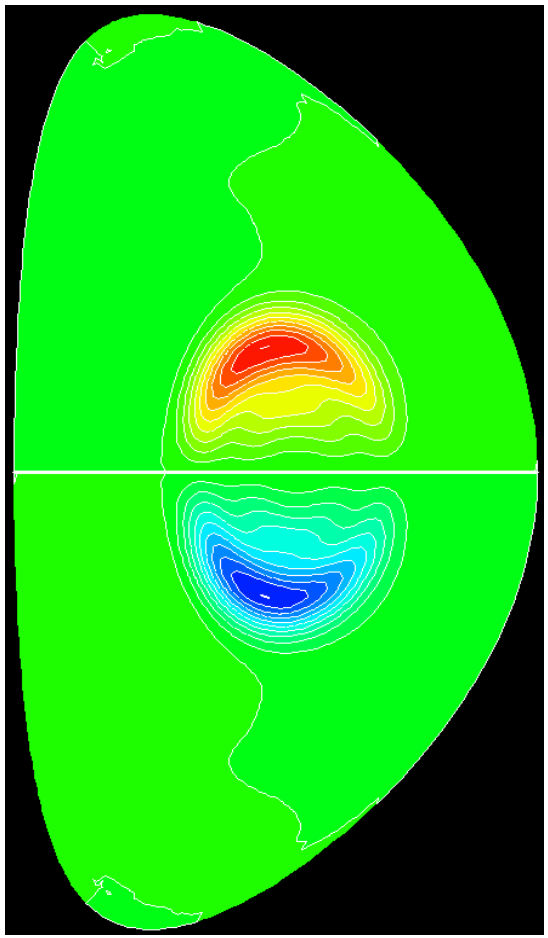
$$\mathbf{E}+\mathbf{v}\times\mathbf{B}=\eta\mathbf{J}-\nabla_\parallel P_e/en-\mathbf{bb}\cdot\nabla\cdot\Pi_e/en$$

$$\partial P/\partial t+\mathbf{v}\cdot P=-\gamma P\nabla\cdot\mathbf{v}+.....$$

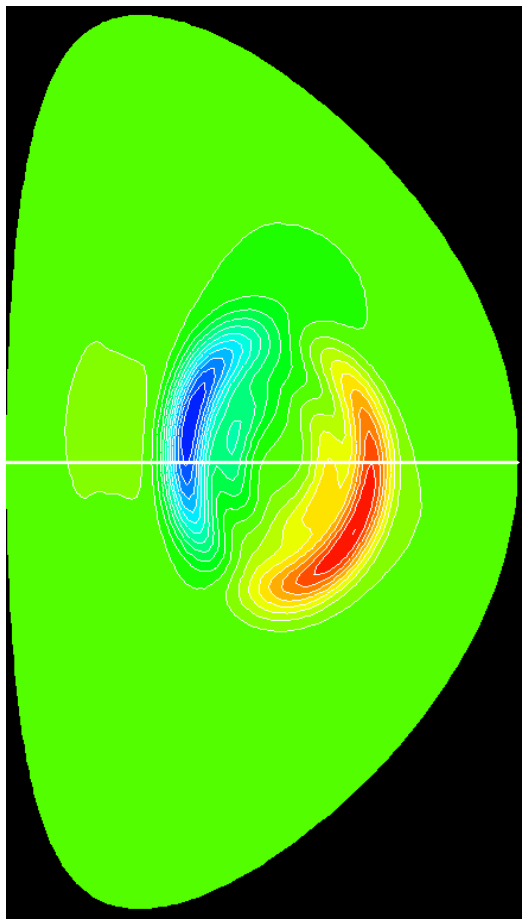
$$\partial P_e/\partial t+\mathbf{v}\cdot P_e=-\gamma P_e\nabla\cdot\mathbf{v}+.....$$

Alpha Particle Stabilization of Internal Kink Mode for ITER:
Internal Kink Mode Structure

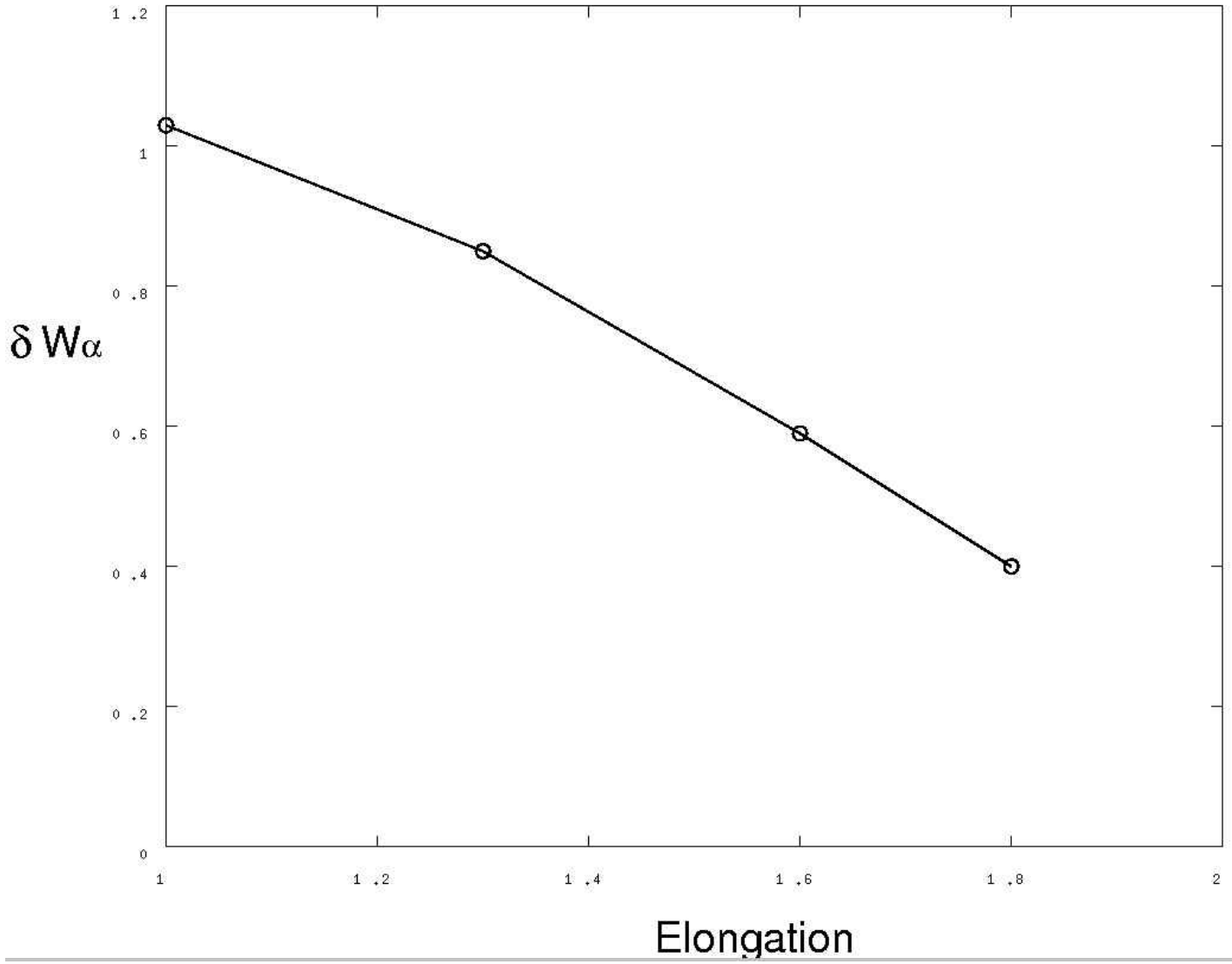
β_α=0.0



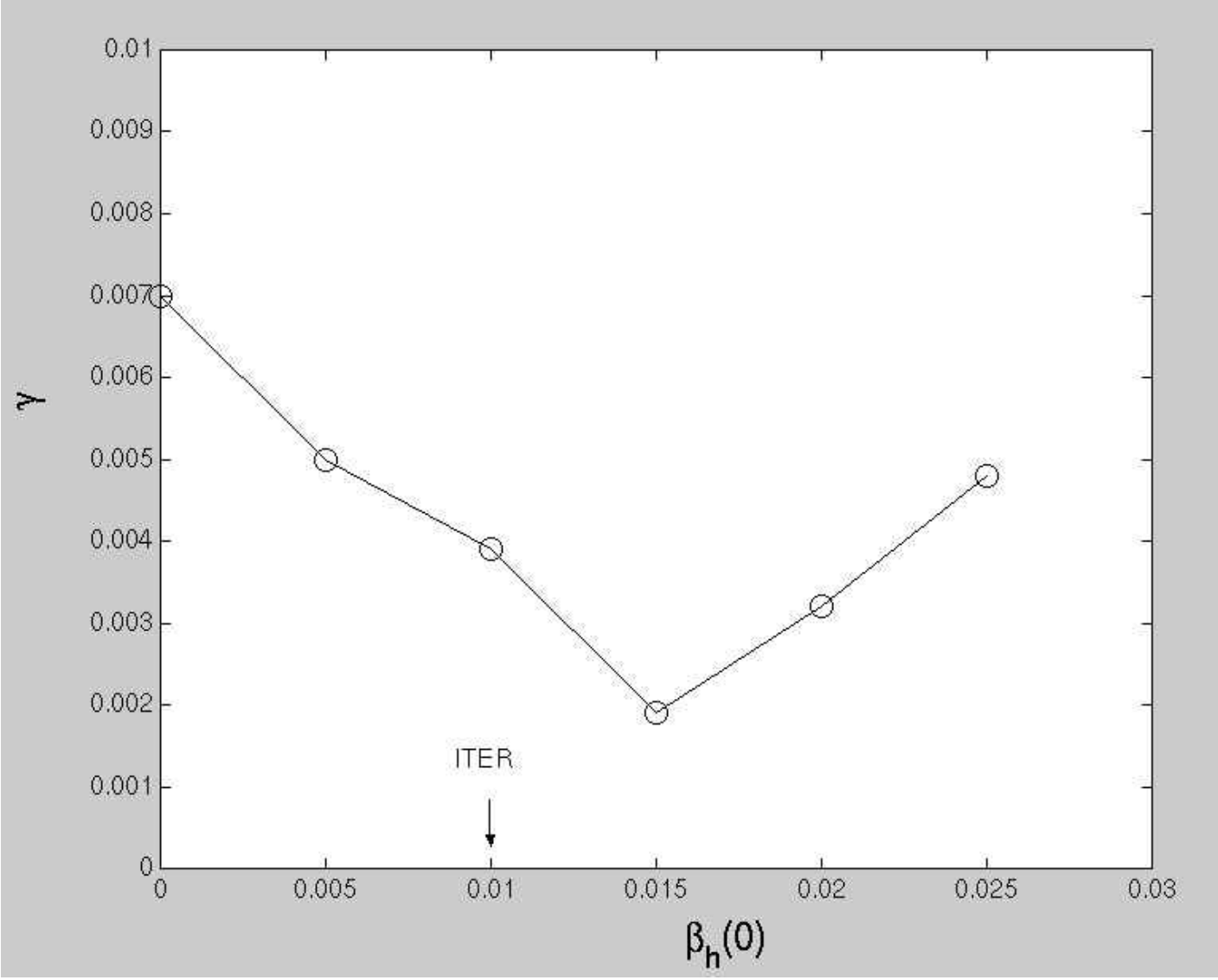
β_α=1.0%



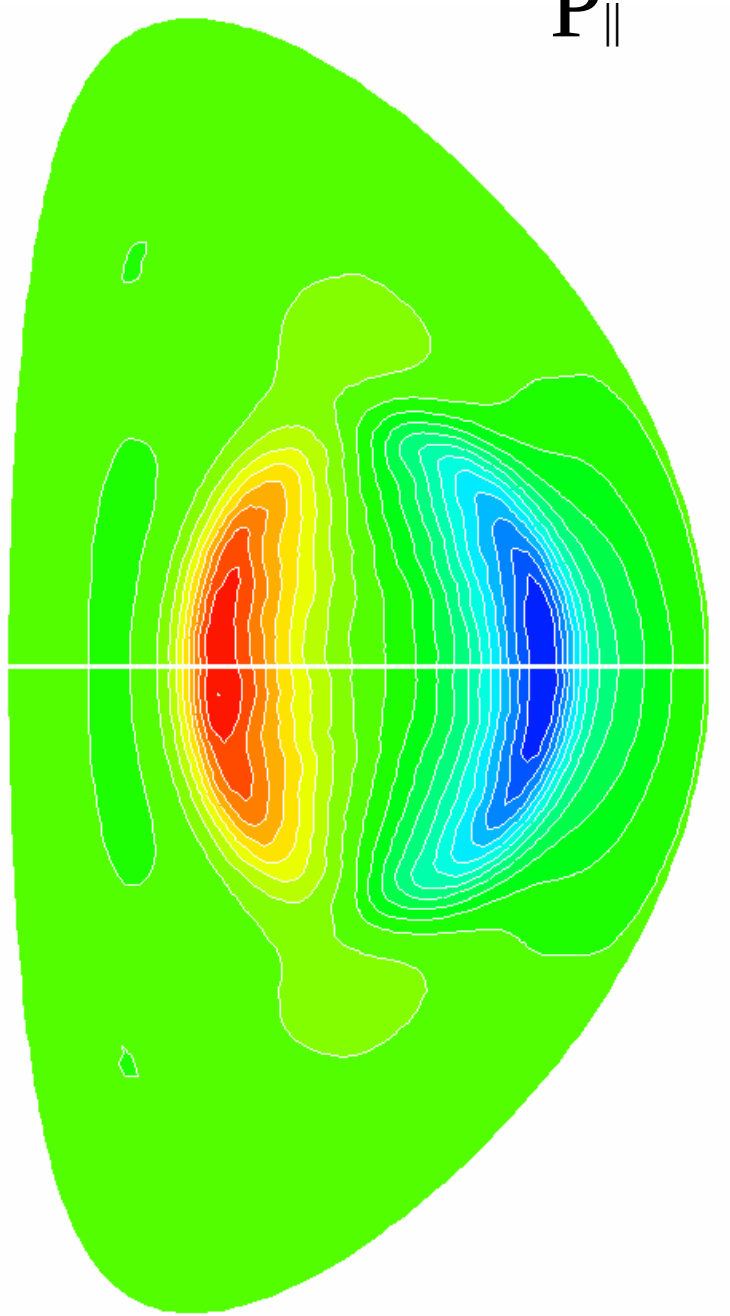
Plasma shaping reduces alpha particle stabilization significantly



The stability of fishbone mode in ITER



Thermal ion kinetic effects reduce MHD growth rate by half (Kruskal-Oberman)



Work in Progress

- Two fluids effects + alpha particles
- Apply high order elements;
- Implicit advance for shear Alfven waves;
- Add more thermal ion kinetic effects (i.e., FLR etc).