

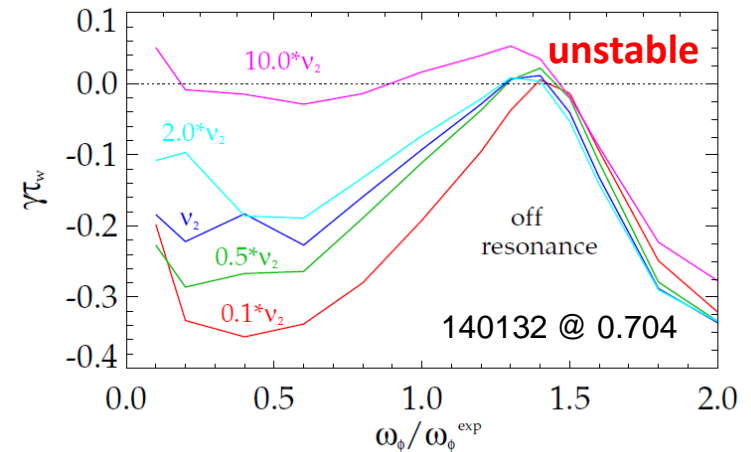
Further development of RWM kinetic stability theory will improve MISK model and comparisons to experiment

Kinetic terms in the RWM dispersion relation enable stabilization:

$$\delta W_K = \sum_j \sum_{l=-\infty}^{\infty} 2\sqrt{2}\pi^2 \int \int \int \left[|\langle H/\hat{\varepsilon} \rangle|^2 \frac{(\omega - n\omega_E) \frac{\partial f_j}{\partial \varepsilon} - \frac{n}{Z_j e} \frac{\partial f_j}{\partial \Psi}}{n\langle \omega_D^j \rangle + l\omega_b^j - i\nu_{\text{eff}}^j + n\omega_E - \omega} \right] \frac{\hat{\tau}}{m_j^{3/2} B} |\chi|^{\frac{5}{2}} d\hat{\varepsilon} d\chi d\Psi,$$

Theory consistent with experimental results.

[J. Berkery *et al.*, Phys. Rev. Lett. **106**, 075004 (2011)]

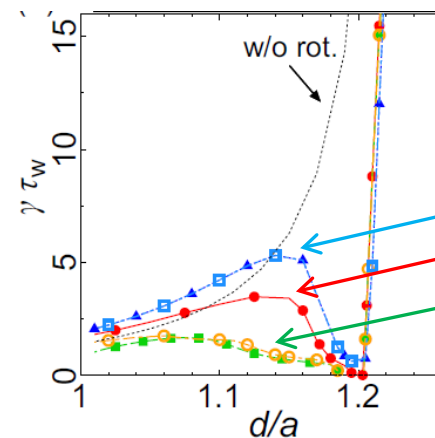


– Collisionality model improvements

- MISK currently uses an energy-dependent collisionality, MARS-K uses a constant.
- Possible improvements: Particle, momentum, and energy conserving Krook operator, or Lorentz operator with pitch angle dependence.

– Further rotation effects

- Effect on equilibrium
- Including poloidal rotation
- Small changes to edge wE can have significant effect: [J. Menard: APS 2010, APS 2011, Nucl. Fusion **50**, 045008 (2010)]



[N. Aiba *et al.*, Phys. Plasmas **18**, 022503 (2011)]

- Ω_ϕ and $\Omega_\theta = 0.05\Omega_\phi/q$
- Ω_ϕ
- Ω_ϕ and $\Omega_\theta = -0.05\Omega_\phi/q$

– Neoclassical orbit modification? (with G. Kagan)

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– Eigenfunction modifications

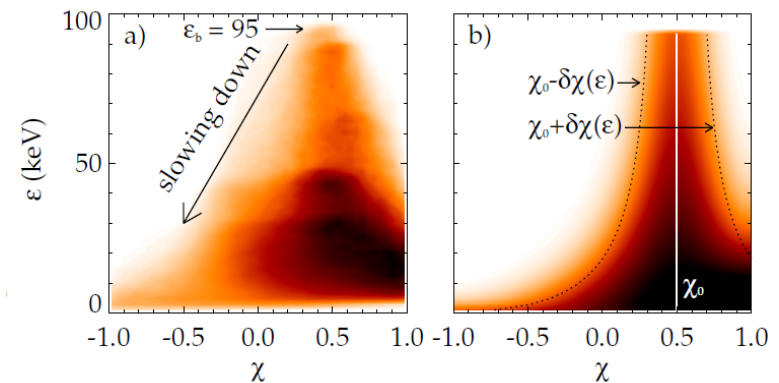
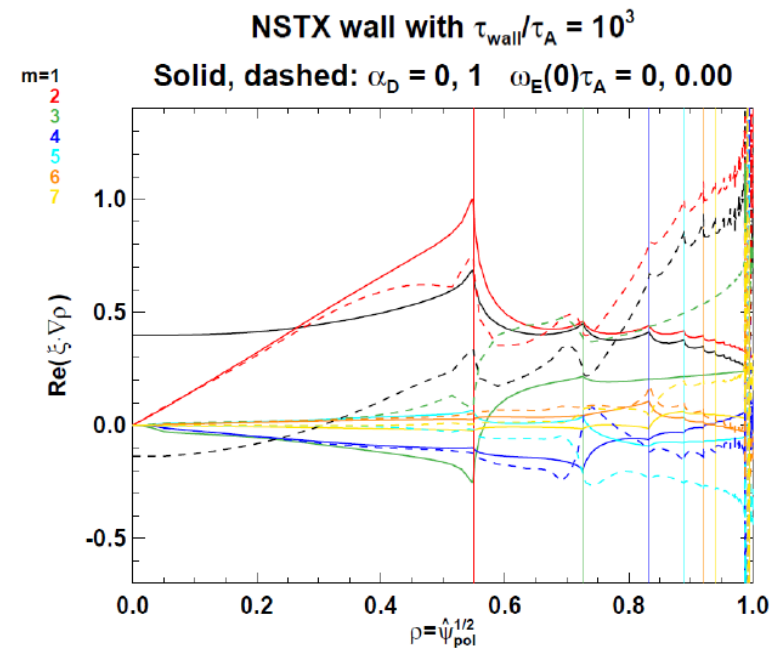
- Due to dissipation, rotation, etc...
- The importance of eigenfunction modification (and Alfvén resonances at rational surfaces) will come out of MDC-2 code benchmarking.

– Anisotropy of energetic particles

- Anisotropy affects fluid terms, mostly through ballooning term.
- Also affects kinetic term, through pitch angle dependence of distribution function.
- Addition of simple anisotropy model reduces stabilizing effect, consistent with quantitative comparison to NSTX.

$$\delta W_F = \frac{1}{2} \int \left\{ \underbrace{\left(-\frac{|\tilde{B}_\perp|^2}{\mu_0} - \frac{B^2}{\mu_0} |\nabla \cdot \xi_\perp + 2\xi_\perp \cdot \kappa|^2 + j_\parallel (\xi_\perp^* \times \hat{b}) \cdot \tilde{B}_\perp \right)}_{\text{shearAlfvén fast magneto-acoustic}} + \underbrace{2(\kappa \cdot \xi_\perp^*) (\xi_\perp \cdot \nabla p_{\text{avg}})}_{\text{kink ballooning}} \right\} dV,$$

$$\delta W_A = \frac{1}{2} \int \left\{ (\sigma - 1) \left(-\frac{|\tilde{B}_\perp|^2}{\mu_0} - \frac{B^2}{\mu_0} |\nabla \cdot \xi_\perp + 2\xi_\perp \cdot \kappa|^2 + j_\parallel (\xi_\perp^* \times \hat{b}) \cdot \tilde{B}_\perp \right) - 2B |\nabla \cdot \xi_\perp + \kappa \cdot \xi_\perp|^2 \frac{\partial p_{\text{avg}}}{\partial B} \right\} dV,$$



[J.W. Berkery *et al.*, *Phys. Plasmas* **17**, 082504 (2010)]