Electromagnetic Effects in NT Plasmas, ECCD, & NT ARC

DIFFER

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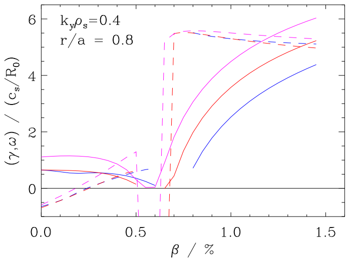
TSVV2 Workshop,
September 23, 2024

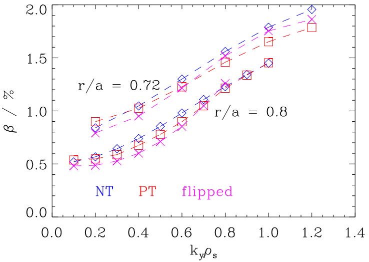
Recap of KBM in TCV

Plan to submit results to APS-DPP special issue in PoP

TCV #69515 (PT), #69340 (NT): matched $\nabla n, T, \beta$, except R/L_{Ti}

PT, NT, and PT+flipped: mixed ITG, TEM, ITG-TEM hybrid

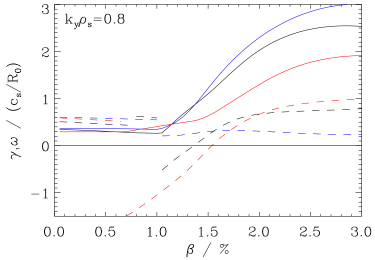




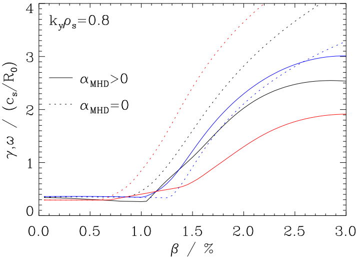
- PT has higher $\beta_{\rm crit}^{\rm KBM}$ than NT, **only due to lower gradients**
- **PT-flipped: lower threshold** than NT
- more substantial increase in $\beta_{\rm crit}^{\rm KBM}$ for more negative δ

Soft KBM Onset

Different TCV #73564 (NT), #73589 (PT): **soft KBM onset**



β-consistent equilibrium ($\alpha_{\rm MHD}$) affects thresholds



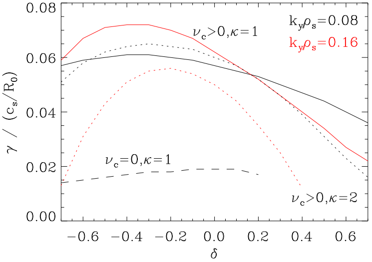
hybrid TEM-KBM or stKBM?

- ongoing characterization using KBM theory (P. Mulholland)
- ongoing $\beta_{\rm MHD}$ evaluation (O. Sauter)
- indications that soft linear onset still above hard NL limit

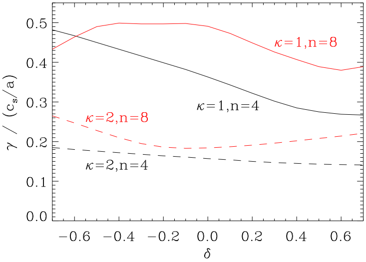
Microtearing

Microtearing: STs, pedestal, sometimes tokamak core;
local, kinetic version of tearing mode, produces $\nabla\tilde{j}$ from ω_{Te}

Core MT (Doerk 2011 + δ):



Pedestal (Pueschel 2020 + δ):



- elongation κ severely, non-trivially affects δ impact
- PT mostly beneficial

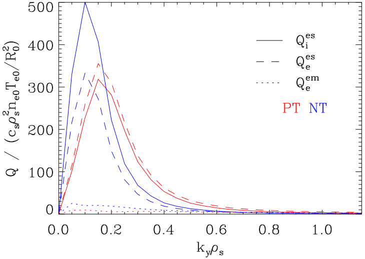
Ongoing (M. Hamed): apply MT theory (Hamed ’19) to NT/PT

Flutter Transport

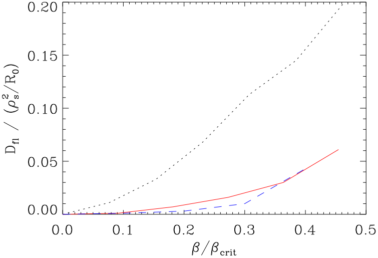
Finite β affects saturation (e.g., zonal flows) of electrostatic turbulence,

also produces magnetic flutter transport Q_e^{em}

Despite substantial ω_{Te}, not much Q_e^{em} in PT, NT?



Strong $|\delta|$: much less field-line diffusion/stochasticity:



$\Rightarrow$ PT and NT both seem to disrupt energy transfer to subdominant MT modes

Other Findings

As reported in earlier TSVV2 meetings . . .

- PT vs. NT can affect proximity to non-zonal transition
- RMP has very limited impact on transport (via zonal-flow erosion) in PT vs. NT

GENE ECCD Implementation

ECCD: electron heating & current drive $\Rightarrow$ impacts $\omega_{T\mathrm{e}}$

However, turbulence also impacts ECCD via beam broadening;
is turbulence affected directly via δT_e, $\delta\Phi$?

resonance width $= 0.3 v_\mathrm{Te}$

deposition power $\sim 10^{-3}$

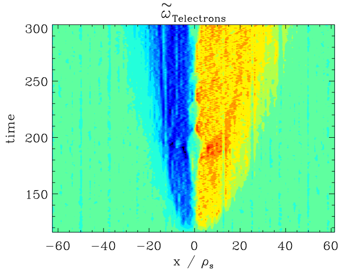
GENE ECCD:
$$\frac{\partial g_\mathrm{e}}{\partial t} = \mathcal{L} + \mathcal{N} + p_\mathrm{EC} \frac{\sqrt{2}}{\pi^{3/2}} \frac{\mu B_0 - 1}{m_\mathrm{e}} \left(\frac{2v_\Delta^2 + 1}{v_\Delta^2} \right)^{1/2} \times \exp\left(-\frac{2v_\Delta^2 + 1}{v_\Delta^2} (v_\| - v_\mathrm{res})^2 \right) \exp(-\mu B_0)$$

resonant velocity $= 2v_\mathrm{Te}$

with Gaussian localization in x, y, z

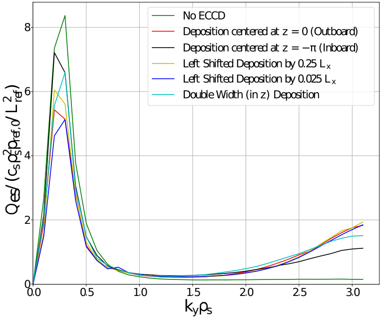
(see Westerhof PoP 2014; implementation: Skyllas & Claassen)

TEM Case



local tripling of ω_{Te}

⇒ **locally destabilizes** (near-marginal) **ETG**

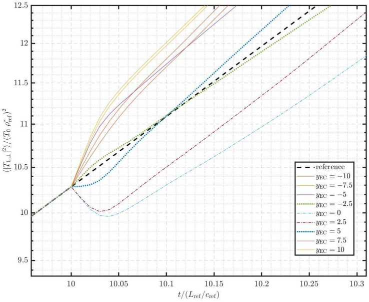


Nonlinearly, **TEM suppressed** by ZF (despite tertiary increase)

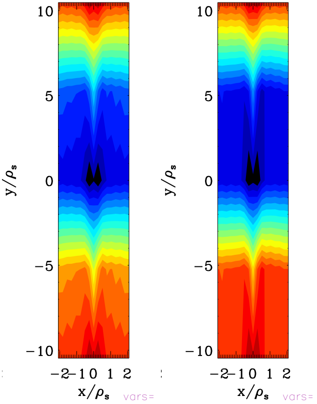
Note: **Asymmetry** in zonal T_e likely **due to TEM**, not ETG

ECCD Instability Control

Use **targeted ECCD** (ongoing, K. Koolen) to suppress modes?



$t = 9.9$: $t = 10.1$:



$\Rightarrow$ depending on deposition location $y_{\rm ECCD}$, enhancement/reduction!

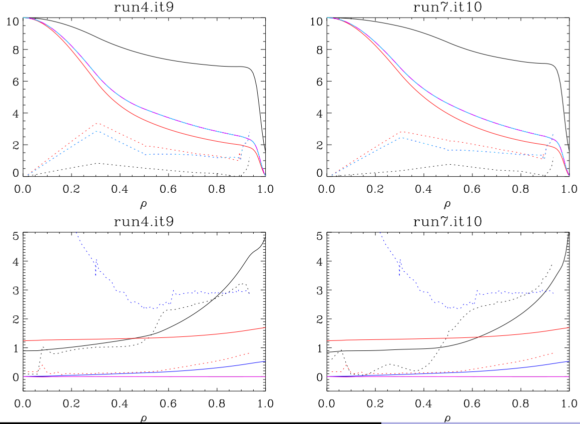
Next: deploy in NL sim's, make experimentally accessible

NT ARC Planning

TSVV2: assess NT reactor relevance → how about ARC?

Requesting input on upcoming NT/PT ARC-Millerized

C. Holland: two ARC scenarios for us to play with:



Proposition:

get fast-ion data (hopefully no unstable AE)

run local at $r/a = 0.3, 0.6, 0.85$

“scan” δ as feasible

ITPA ITER HPI

Suggested text:

TC-32 on negative triangularity and plasma shaping can contribute primarily to “B.12.3 Develop alternative small ELM/no-ELM regimes ITER operation scenarios” and, relatedly, to “B.2.8 Evaluation of small/no ELM H-mode regimes potential to provide high Q operation in ITER” and “B.10.5 Improve ITER IMAS scenario modelling capabilities by experimental validation” by identifying configurations with substantial shaping where good confinement without ELMs can be achieved. Corresponding configurations on existing devices such as DIII-D, TCV, and ASDEX Upgrade can be used for validation of modeling frameworks. The feasibility and necessity to achieve moderate upper) negative triangularity can be assessed.

Suggested classification:

Category 2. The outcome of R&D is expected to have medium impact on system design or on the IRP (e.g. modifying significant details of the experimental strategy to achieve objectives in each phase)

Acknowledgements

This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.