Electromagnetic simulations of Alfvenic instabilities

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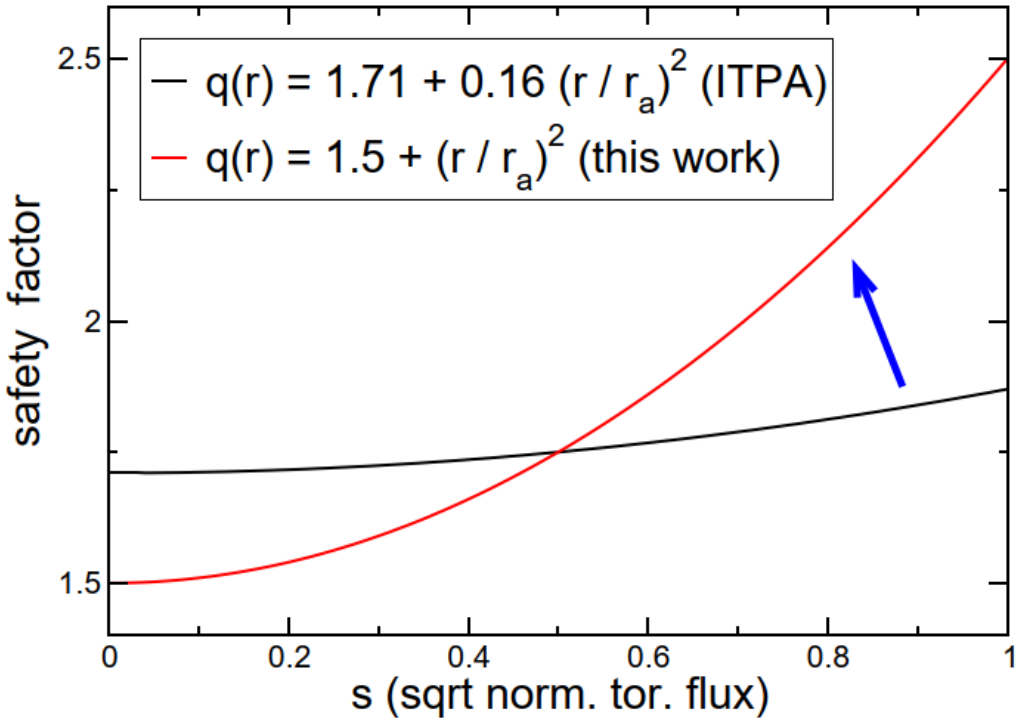
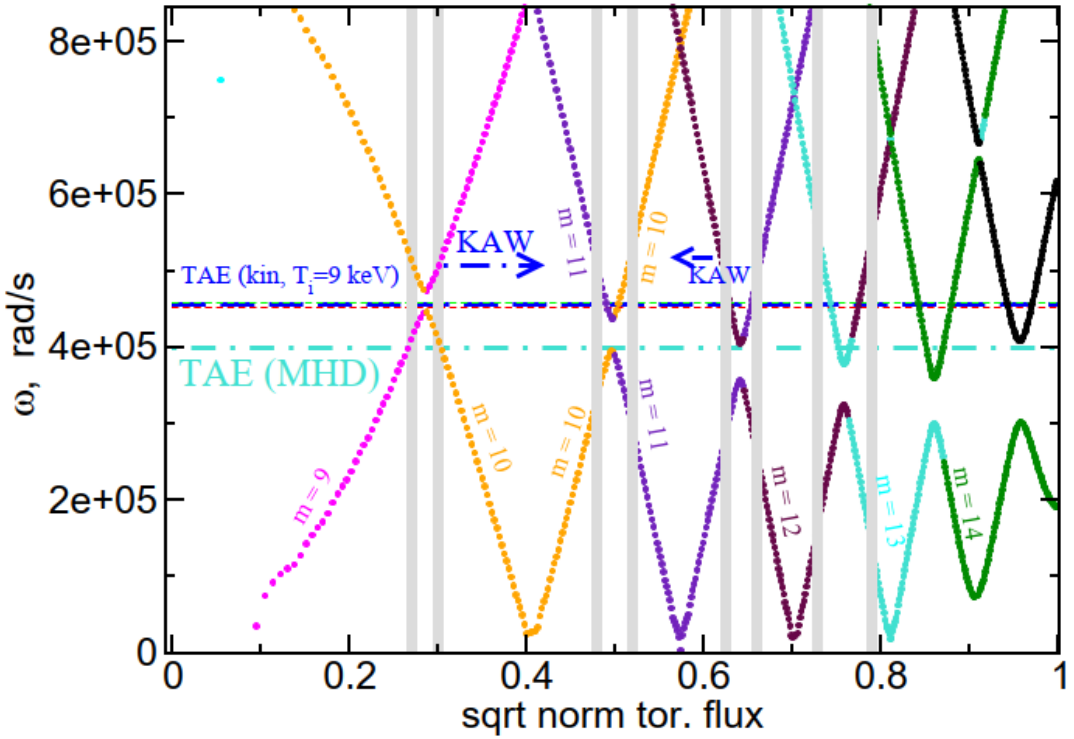
Effect of shear Alfvén continuum: multiple TAEs, Kinetic Alfvén Waves

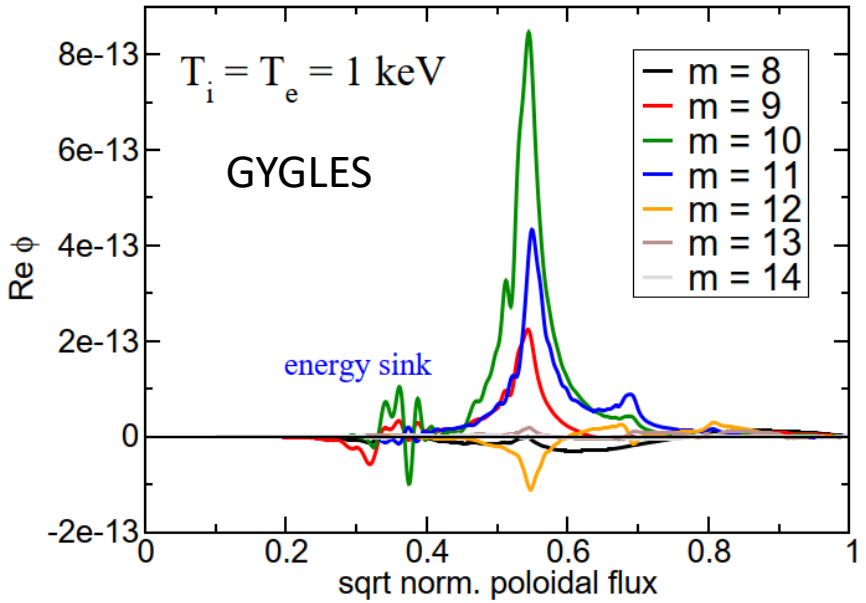


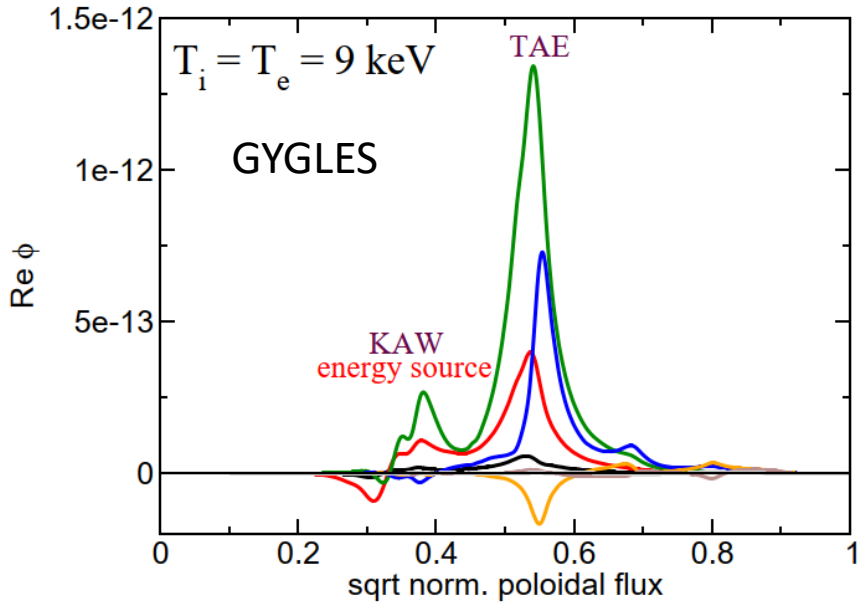


Steeper safety factor profile: more gaps, more interaction with continuum
Leakage of TAEs into neighbouring gaps, radially propagating KAWs

GYGLES simulations: *Phys. Plasmas* 21, 052114 (2014)
How an Eulerian code (e.g. radially-global GENE) performs w.r.t. interaction with the continuum?

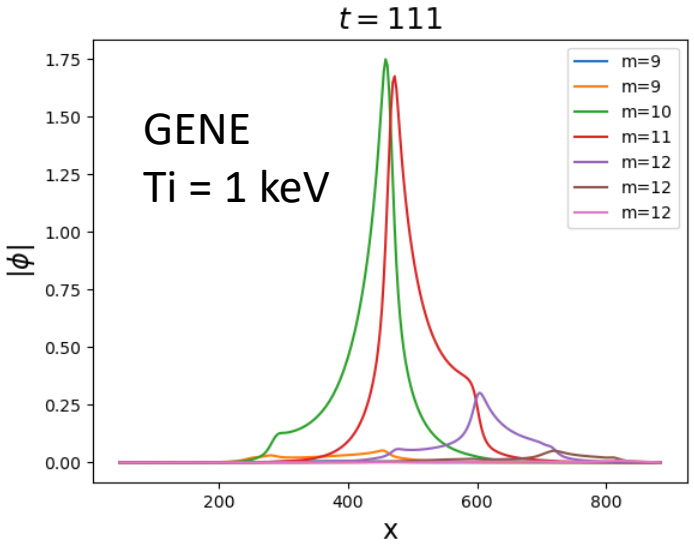
Effect of shear Alfvén continuum: GENE vs. GYGLES

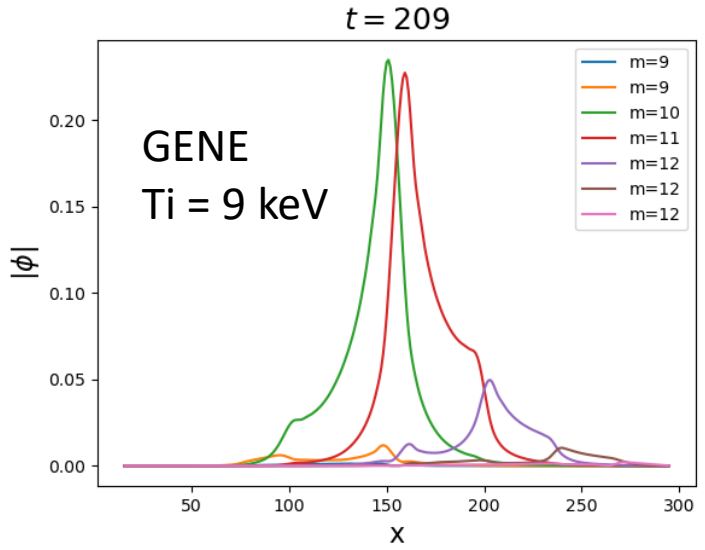




GYGLES shows strong coupling to the continuum

Interaction depends strongly on bulk-ion temperature (ρ_s)

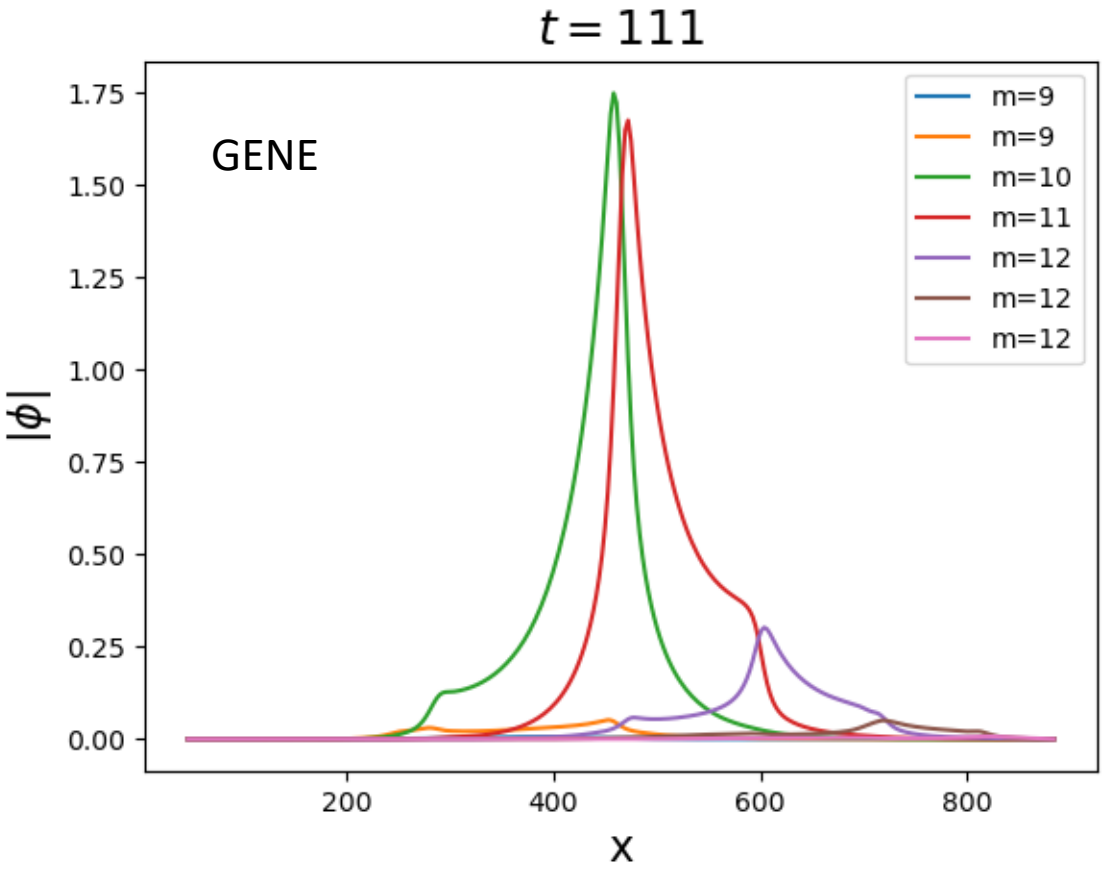


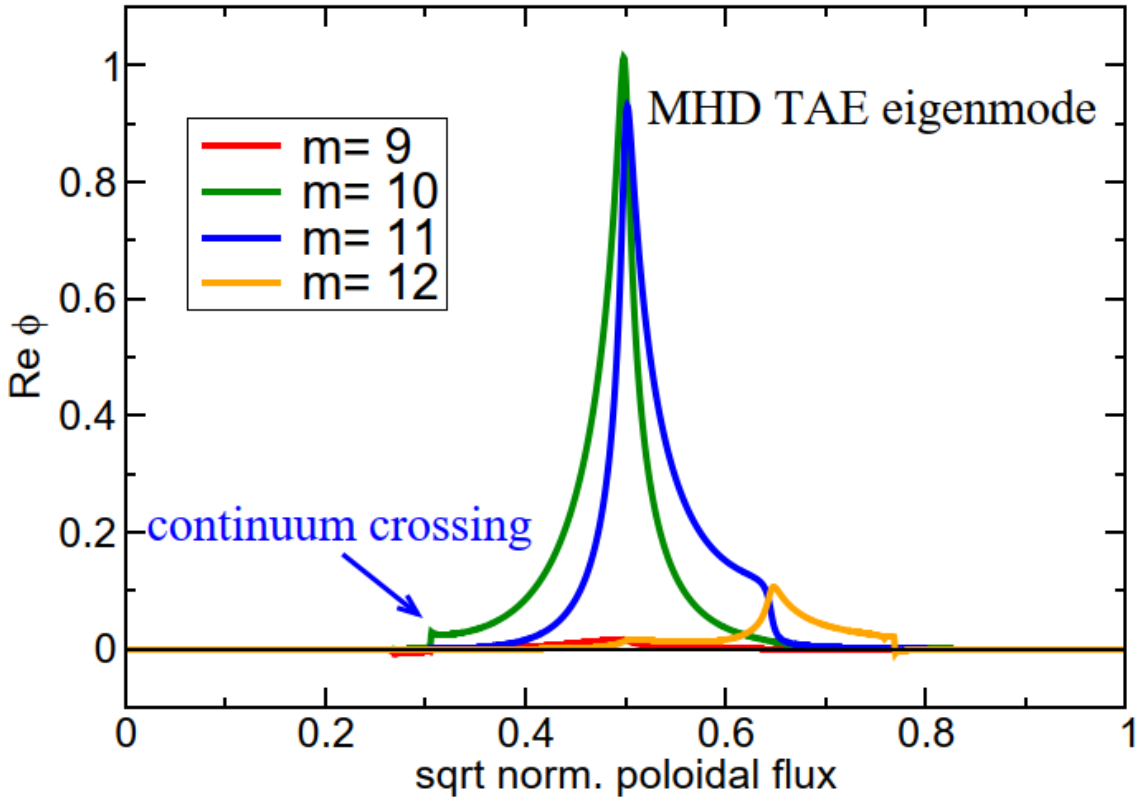


GENE interacts only weakly with the continuum

Mode structure does not change much with the bulk-ion temperature (ρ_s)

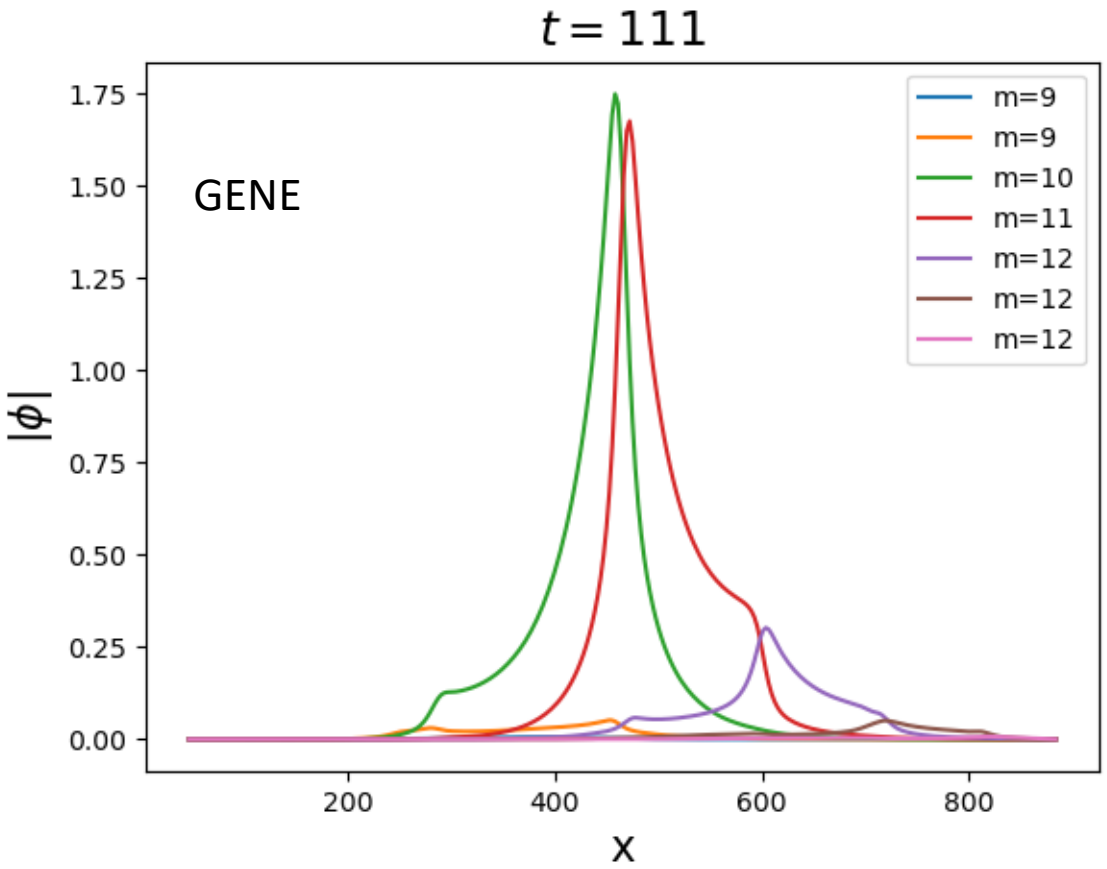
Effect of shear Alfvén continuum: GENE vs. GYGLES

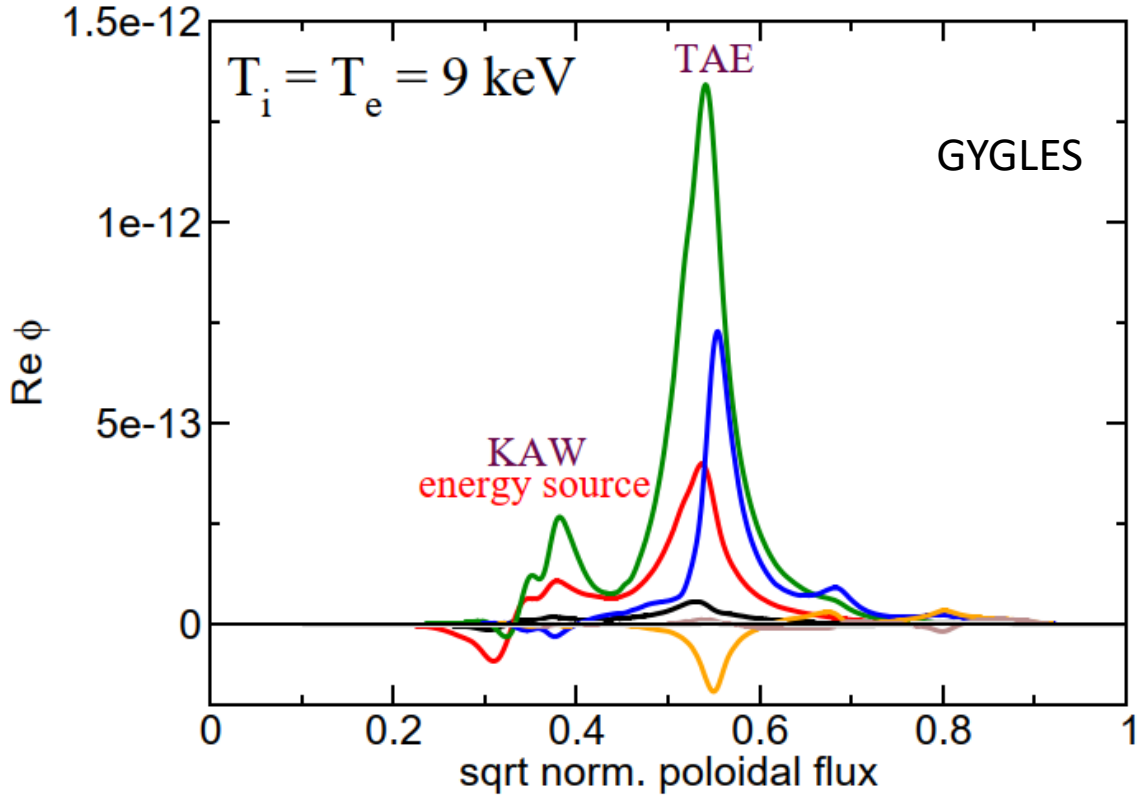




In fact, GENE mode structure compares well to the MHD Eigenmode (for all bulk-ion temperatures).
Generation of kinetic Alfvén waves (continuum interaction) is strongly suppressed.

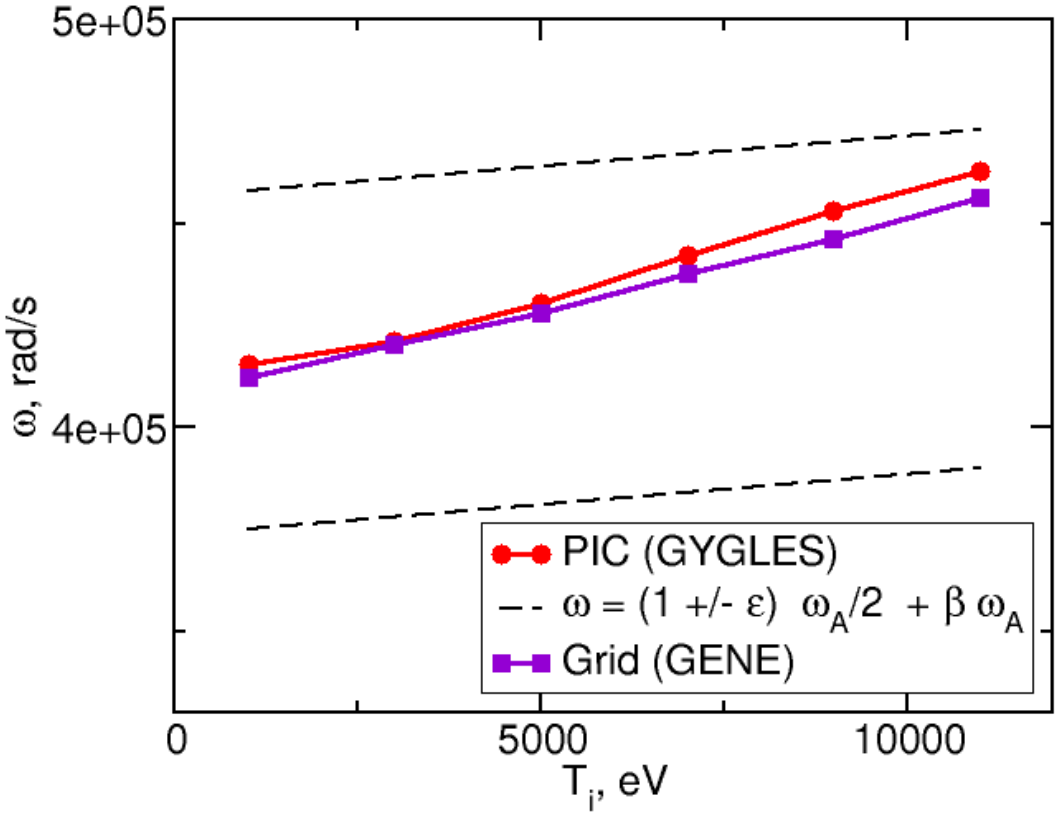
Effect of shear Alfvén continuum: GENE vs. GYGLES

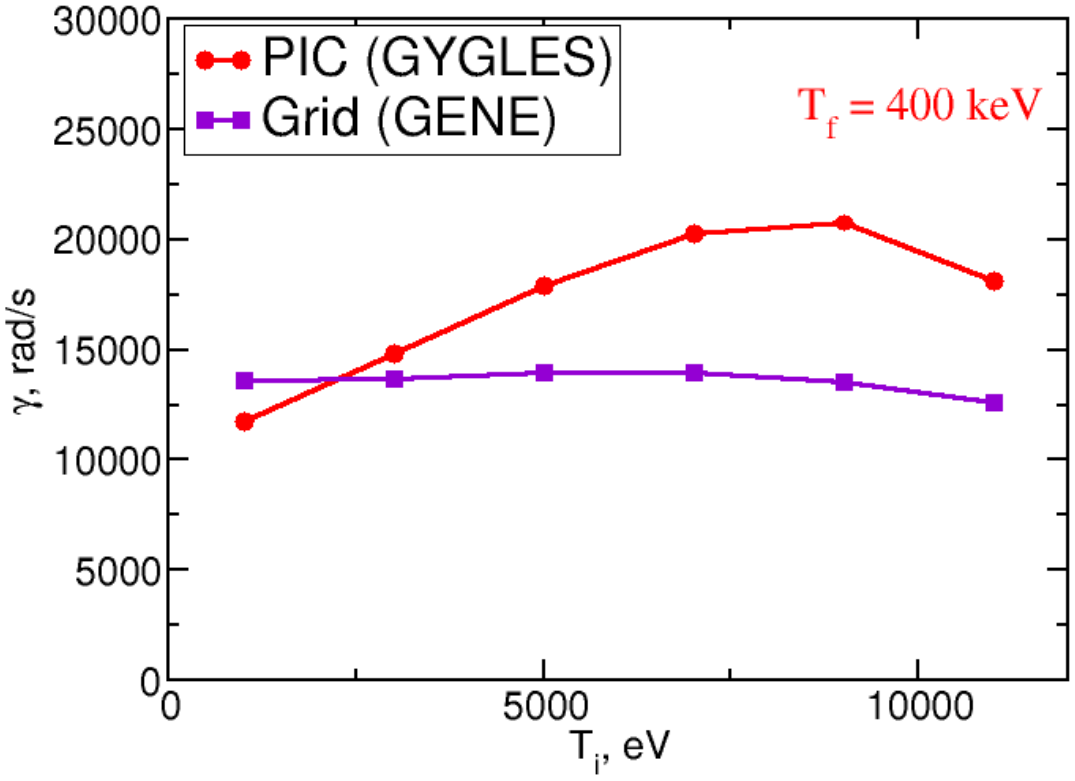




The kinetic mode structure with KAWs (as in GYGLES) does not appear.
Increasing radial resolution (nx0) has not resolved it.
Interaction with the continuum on the grid(?): radial scales (gyro-radius), velocity scales (μ), gyro-average

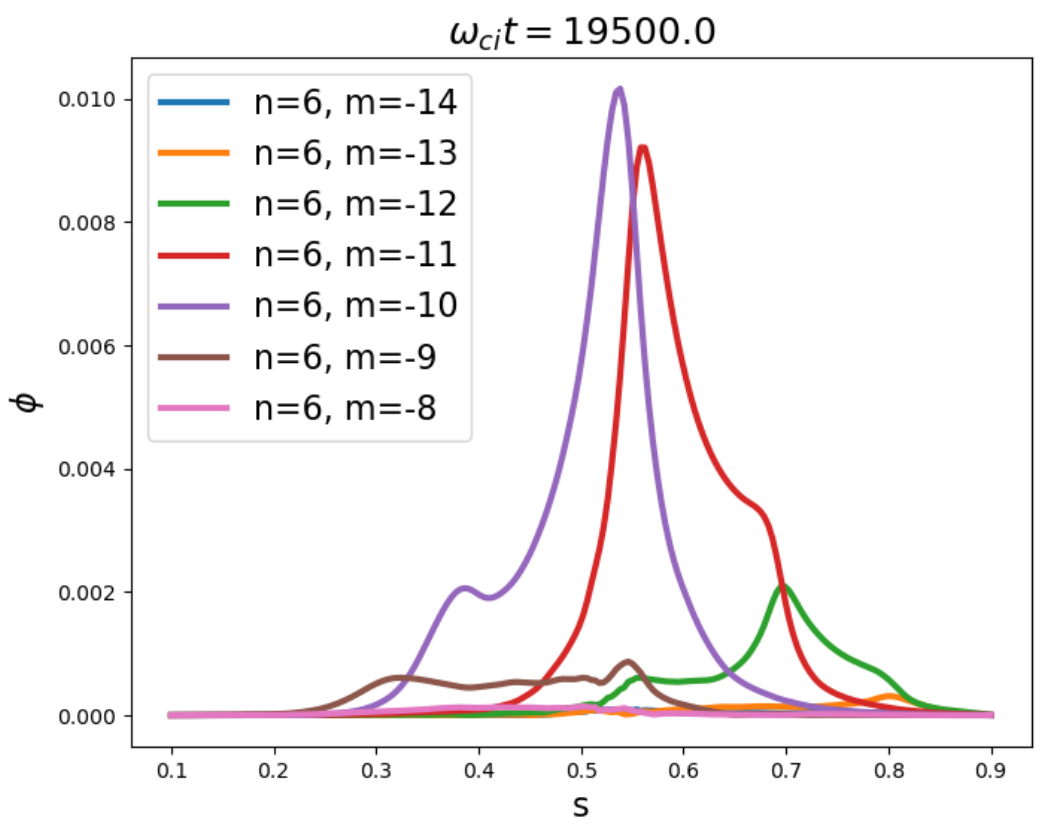
Effect of shear Alfvén continuum: GENE vs. GYGLES

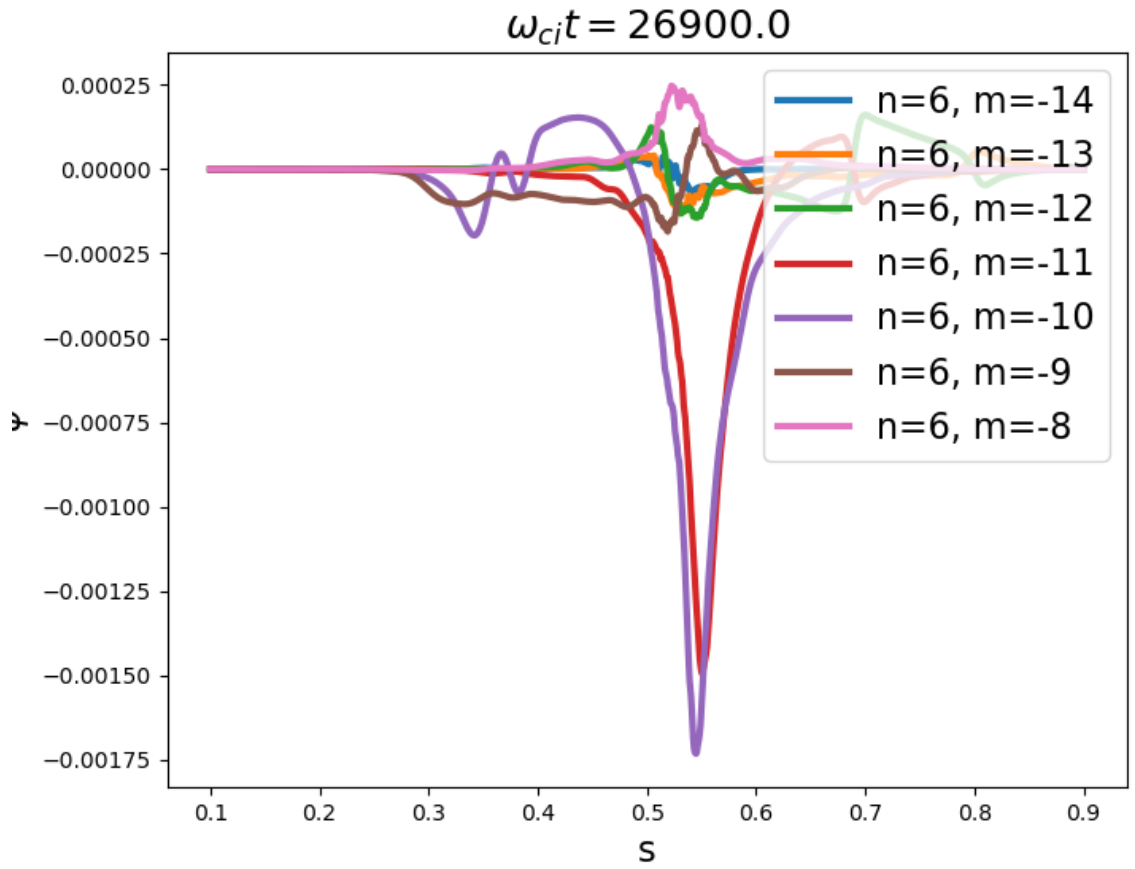




The mode frequency is in a good agreement; growth rate differs.
It seems that KAWs are suppressed.

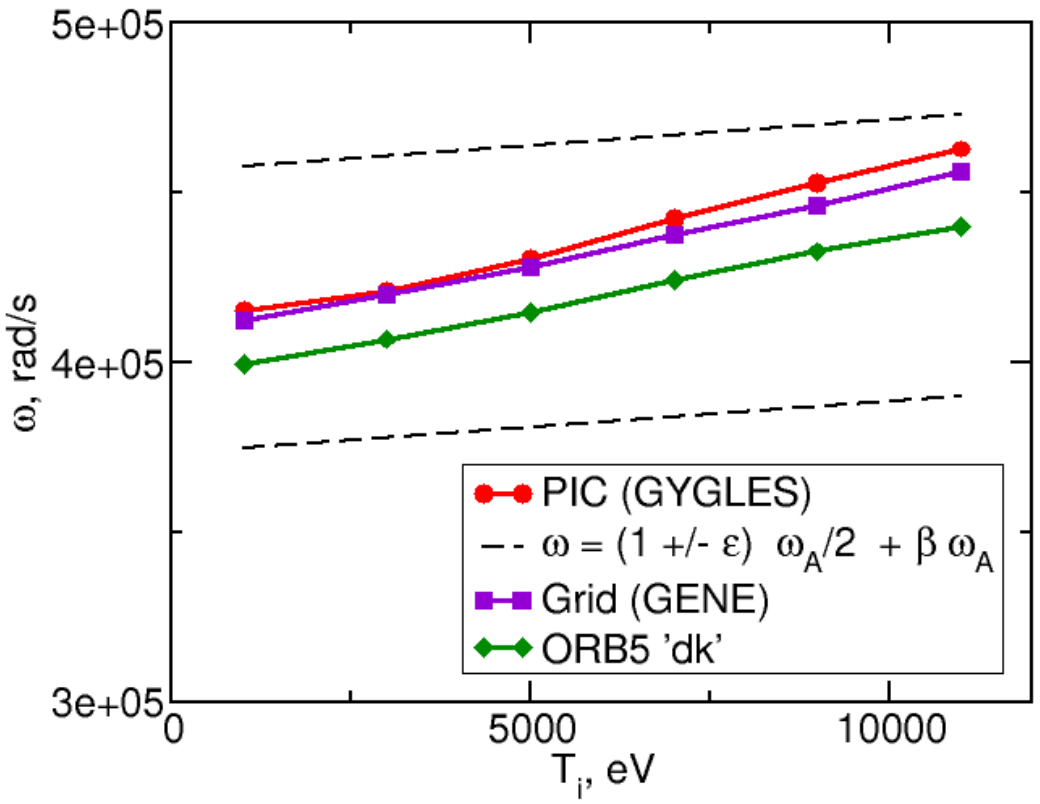
Effect of shear Alfvén continuum: GENE vs. GYGLES

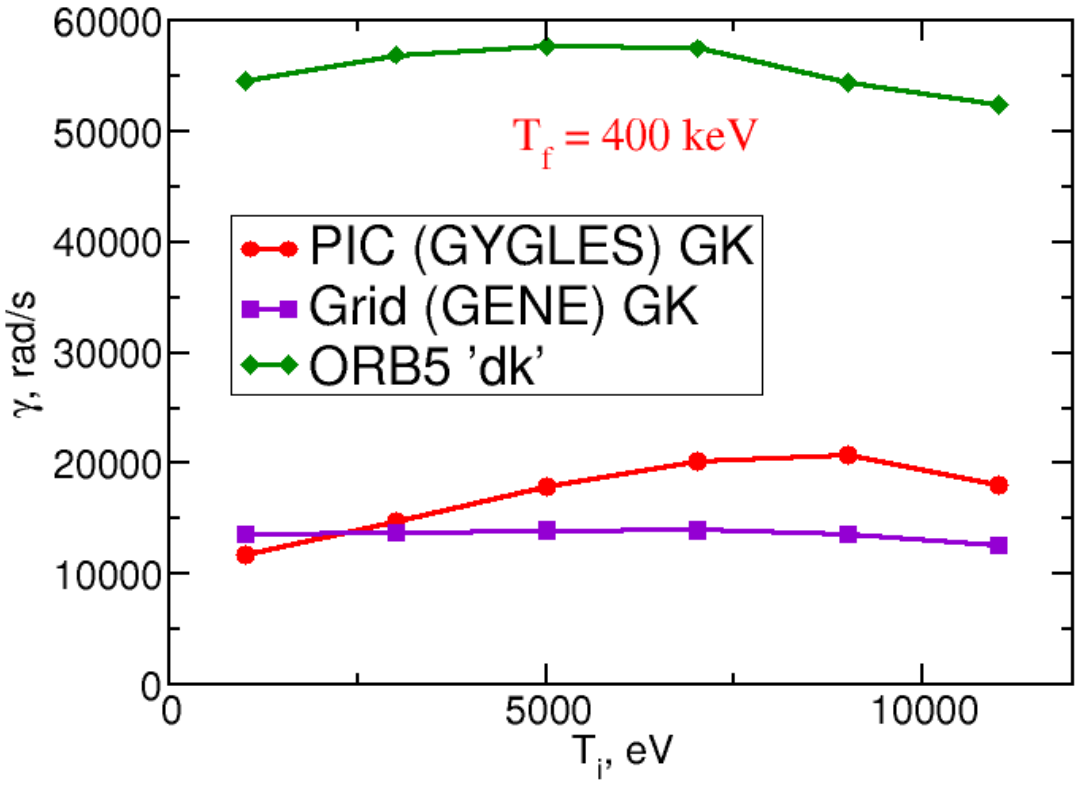




Left: ORB5 with dk ions → pattern similar to GENE
Right: ORB5 with gk ions → pattern similar to GYGLES

Effect of shear Alfvén continuum: GENE vs. GYGLES





The mode frequency is in a good agreement; growth rate differs.
It seems that KAWs are suppressed.
But, FLR in GENE is present!

1) Is gyro-average equivalent to ORB5?
2) Is radially-global GENE equivalent to 3D?

Conclusions

- Plasma confinement depends on interplay of turbulence, zonal flows, energetic particles, Alfvénic and MHD waves
- Global gyrokinetics is the most inclusive approach
- Electromagnetic simulations are necessary to include all these parts
- Flux-tube simulations in the electromagnetic regime may be problematic (large boxes, kinetic Alfvén waves)
- Linear TAE compares very well for GENE and GYGLES (mode structure, frequency, growth rate)
- CFL Time step strongly decreases for higher EP energy (towards fusion values)
- Problems in the nonlinear stage (for same parameters): can be resolved using the appropriate scheme
- Generation and propagation of KAWs seems suppressed on grid; MHD structure and frequency reproduced
- Suppression of KAWs modifies growth rate of the TAE with strong continuum interaction

- OUTLOOK: integration of different gyrokinetic tools for EP problems, careful comparison