Considerations on electromagnetic microstability of quasi-axisymmetric stellarators

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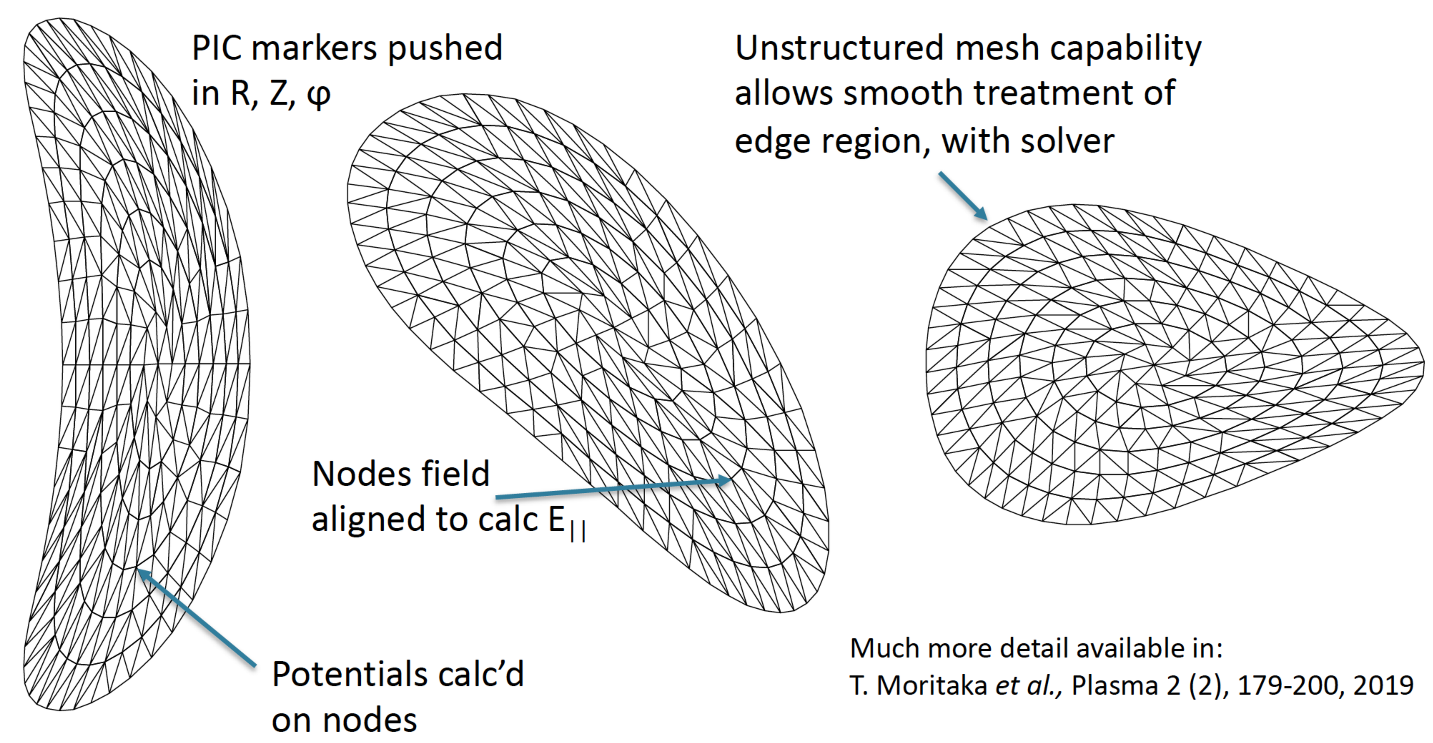
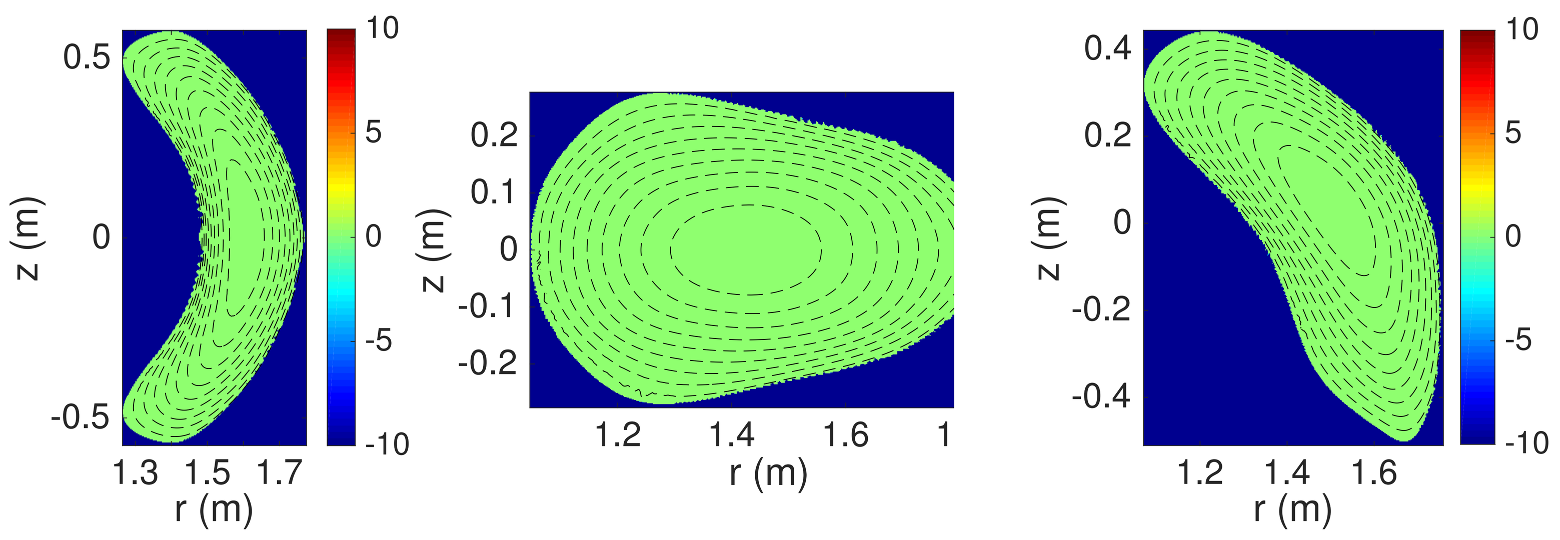
XGC-S global gyrokinetic code

- XGC is a **total-f** gyrokinetic PIC code for **whole volume** plasma simulation.
- Stellarators primarily use coil shaping to generate B_{pol} and have many favourable properties, such as inherently steady-state, disruption-free operation.
- In Wendelstein 7-X neoclassical transport is small enough that turbulence can dominate → gyrokinetic simulations needed to understand stellarator turbulence.

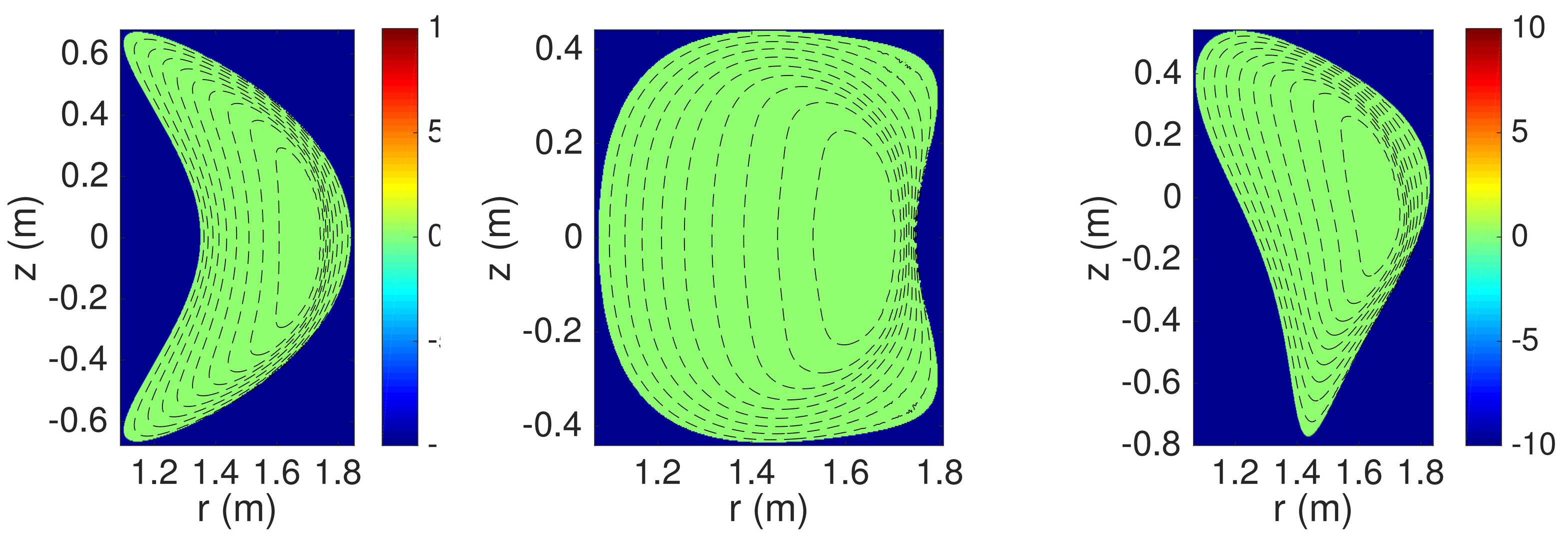


C82 and NCSX equilibria

- NCSX (National Compact Stellataror eXperiment) was a quasi-axisymmetric stellarator designed and partially built at Princeton. This configuration, with flux surfaces at interval $\Delta s = 0.1\Psi_{LCFS}$, are plotted below at zero, π and 2π locations toroidally in one field period.



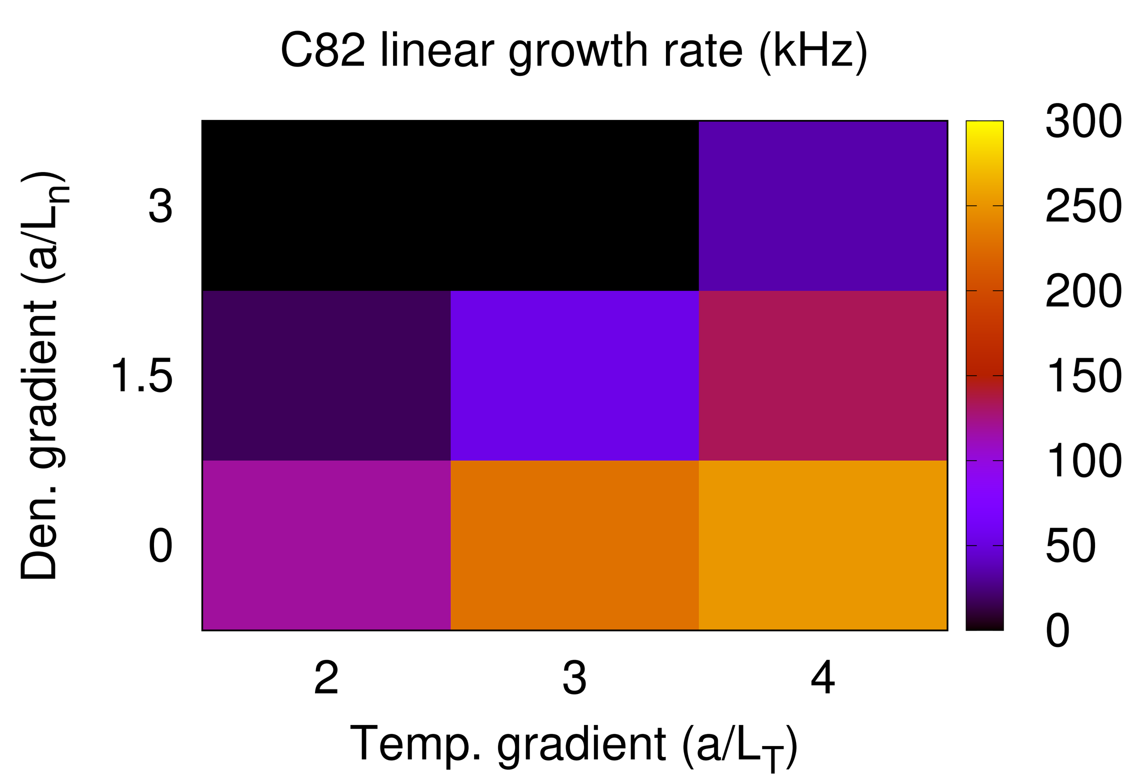
- NCSX was derived from an earlier configuration, C82, by the addition of a vacuum magnetic well. C82 cross-sections are plotted below. The NCSX configuration had improved MHD stability and simpler coils, but these may no longer by key considerations in stellarator optimization.



- Turbulence properties of neither configuration were investigated at that time (~2000)

Linear stability of C82

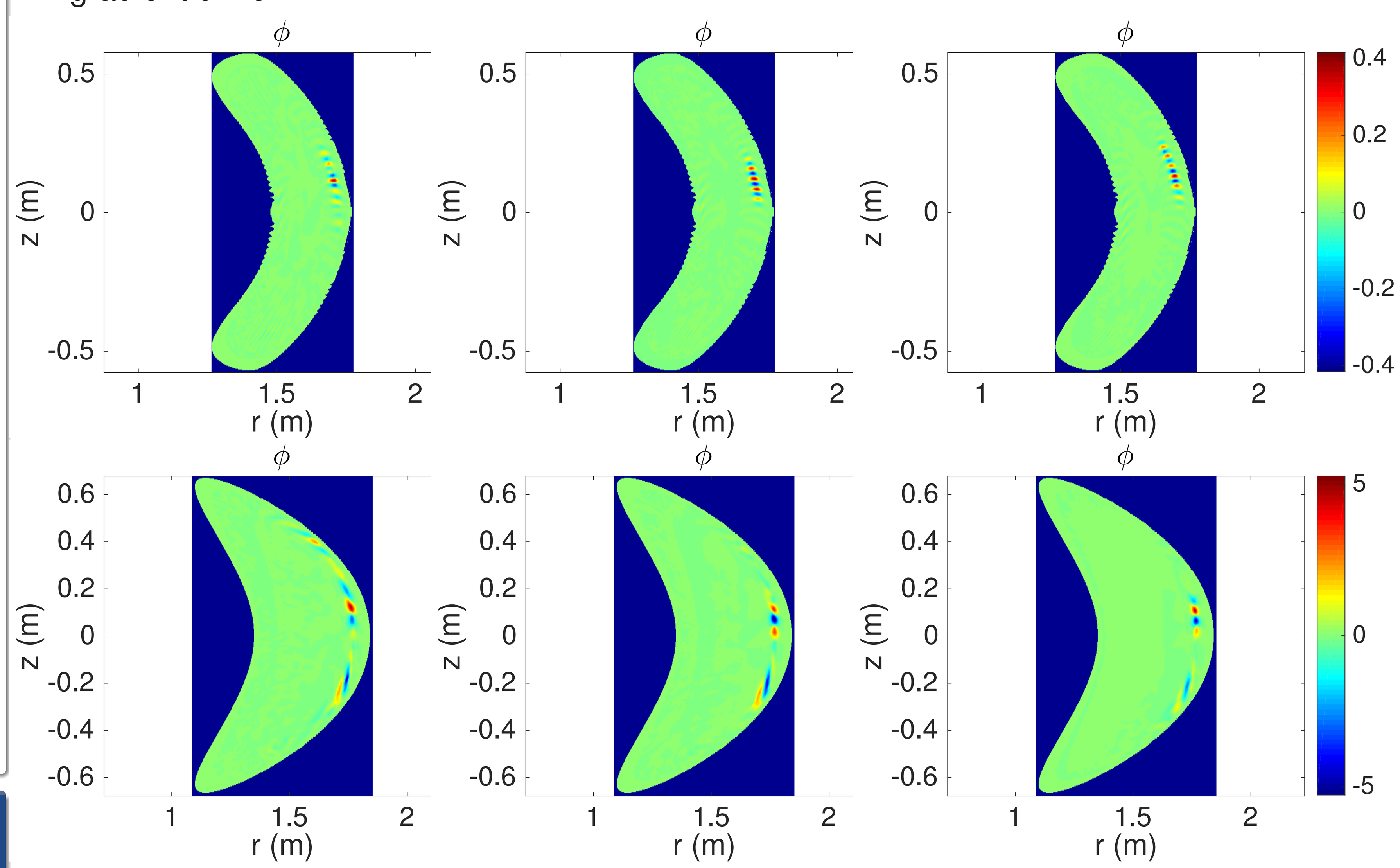
- Linear growth rates are calculated for C82 in density and temperature gradient.



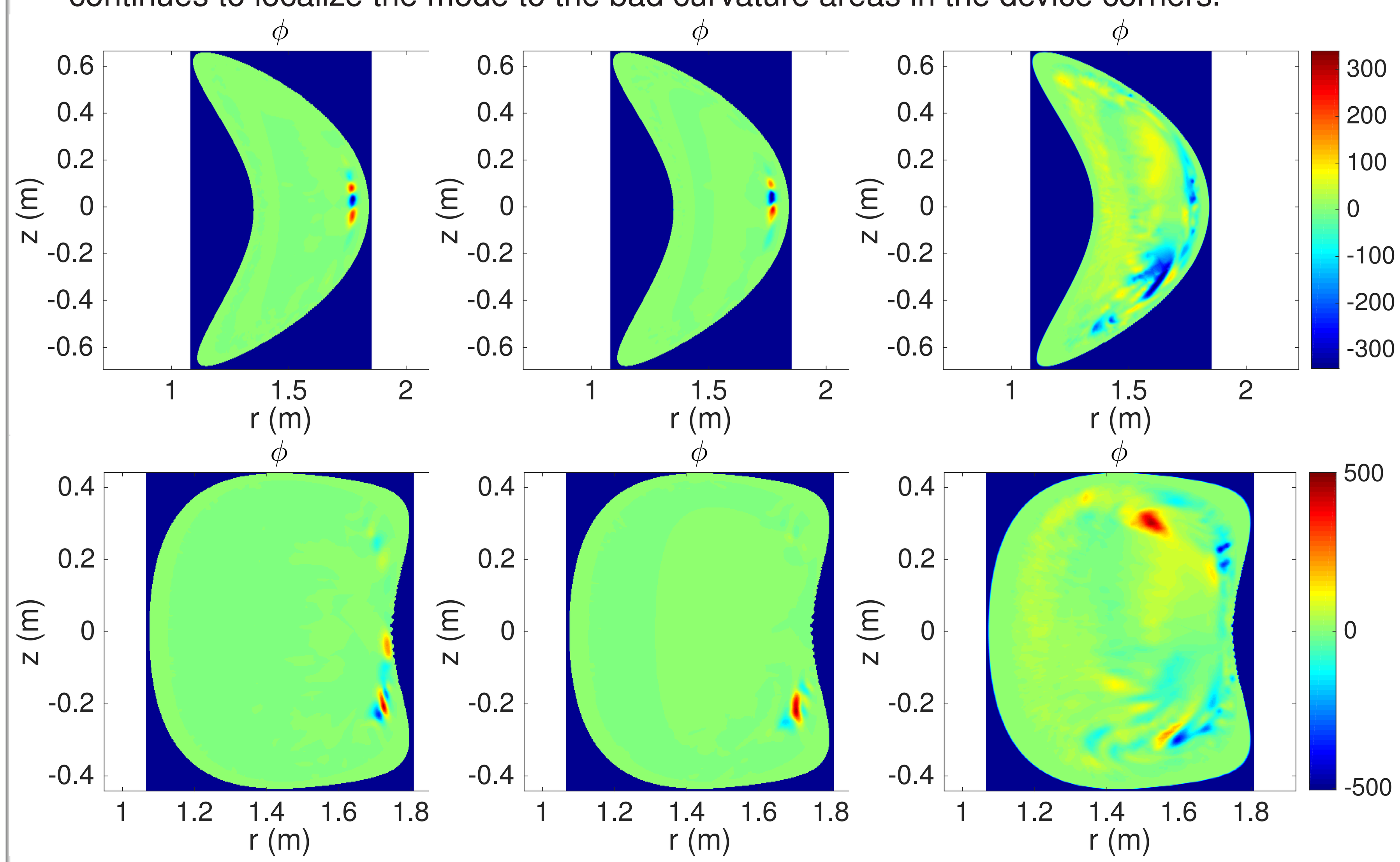
- Stabilization of electrostatic ITG by density gradient is observed.

C82 and NCSX turbulence comparison

- Linear physics: compare NCSX and C82 linear ITG eigenmodes with increasing temperature gradient drive.



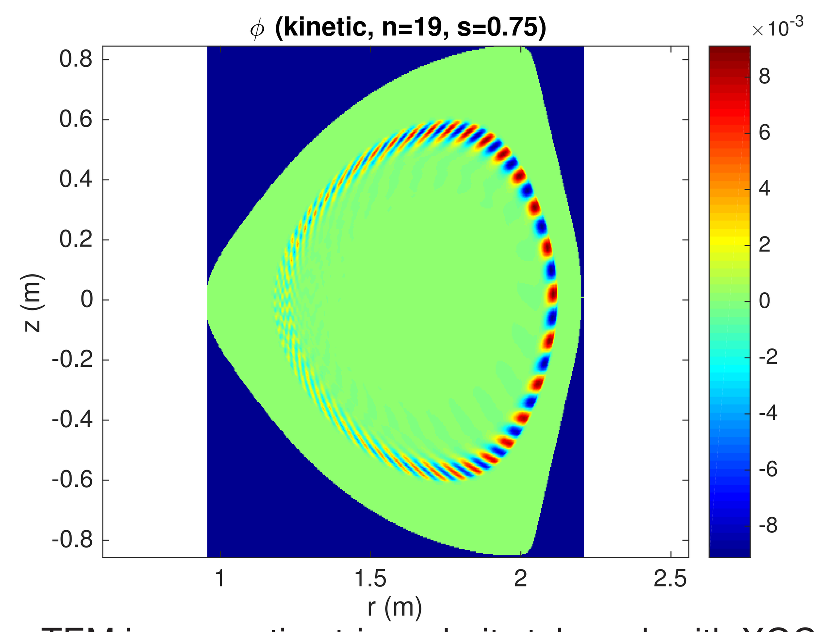
- Localization of fastest-growing mode to one flux tube is an expected finding from analytical and numerical work. Shift in poloidal angle is expected proportional to temperature gradient drive, suppresses linear growth as mode swept out of location of worst curvature.
- Poloidal shift of ITG mode is not observed for C82.
- Below, the evolution of the ITG mode structure into the nonlinear phase. Strong shaping continues to localize the mode to the bad curvature areas in the device corners.



- This nonlinear mode localization was not observed in NCSX - opportunity for turbulence optimization?

Negative triangularity QAS

- A negative-triangularity Quasi-Axisymmetric Stellarator could combine several good features for turbulence performance.
- Intelligent shaping of the geometry could localize ITG as in C82.
- Tokamak work has shown that negative triangularity can suppress trapped electron mode (TEM) turbulence.
- Unlike in some omnigeneous stellarators, zonal flows should be relatively unimpeded by good quasi-axisymmetry.



TEM in a negative-triangularity tokamak with XGC.

Bibliography

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