Status: QAS3 Configurations with Increased Elongation

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- C82-like configurations have been found to be stable to vertical displacement modes for elongation up to ~ 4.
  - Potential of increasing kink and ballooning stability margin by further increasing the shaping, thereby raising the stability beta limit.
- We have:
  - studied the effects of increasing elongation on properties of C82.
  - found means to modify C82 to increase βcrit as elongation is increased.
  - renewed the search for a stable, quasi-axisymmetric configuration starting from a κ=2.5 tokamak.

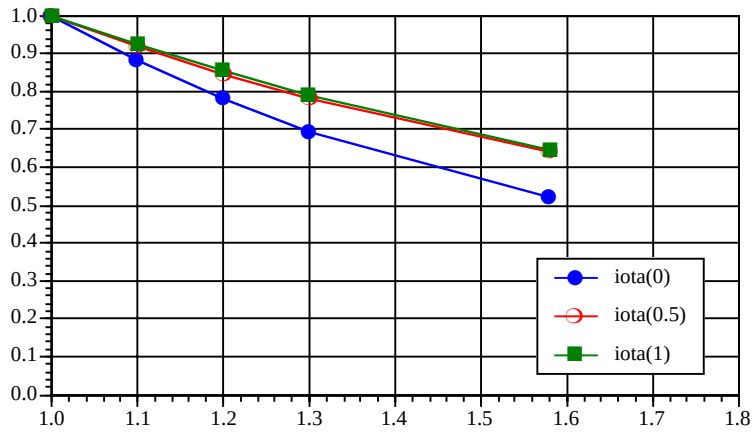
Effects of Increasing Elongation on Properties of C82

- The following were held fixed:
  - pressure and current profiles (Aries reference profiles)
  - current density J => Ip $\propto \kappa$, κ = elongation.
  - B_0 (toroidal magnetic field), and hence, $\langle\beta\rangle$ ~ fixed => $\Phi \propto \kappa$
  - all boundary terms, except Z(1,0).

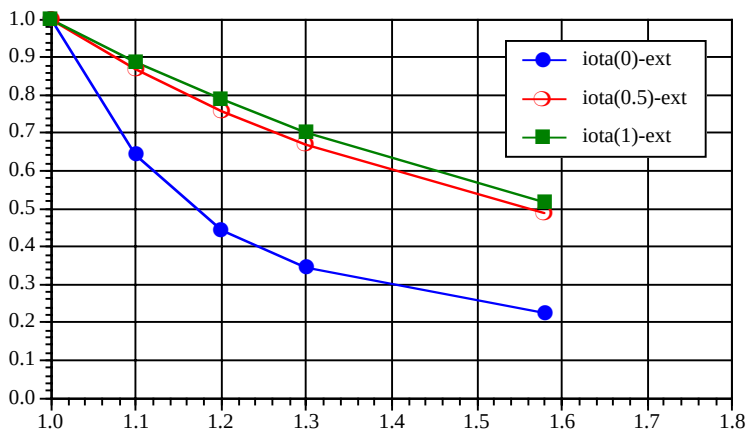
- Iota decreases as κ increases.
  - Total iota decreases at about the same rate as the increase in κ (=> ~ constant poloidal flux).

- However,
  - The external transform decreases faster than the internal transform,
  - Iota in the center also decreases faster than at the edge.

Rotational Transform Versus Elongation



Total Transform

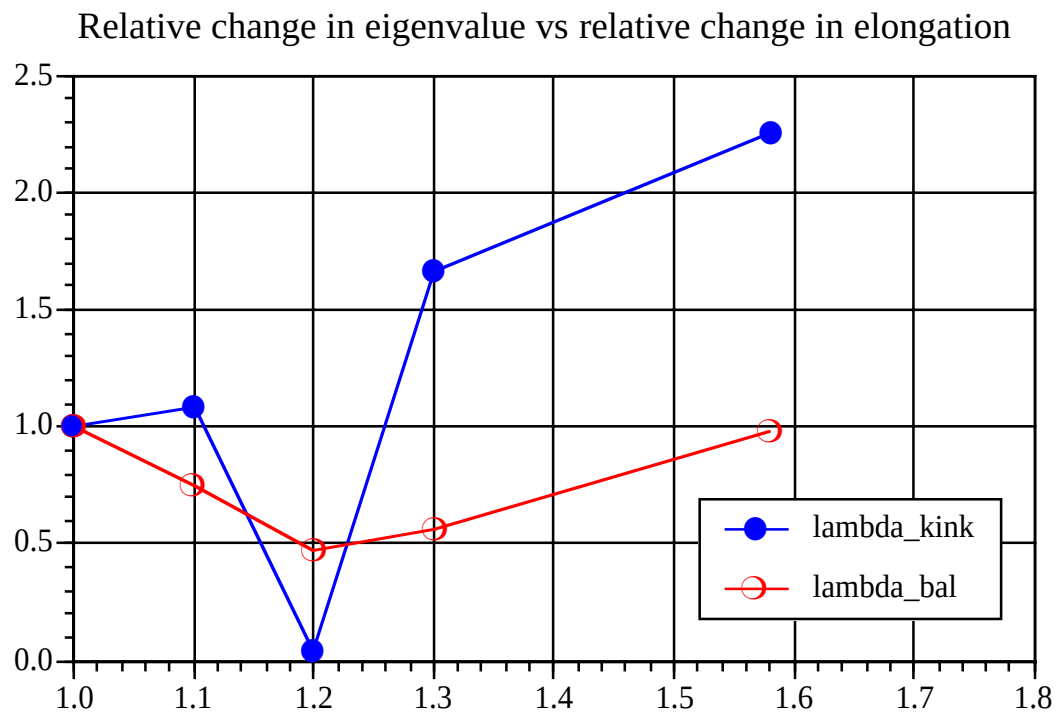


External Transform

κ/κ(c82)

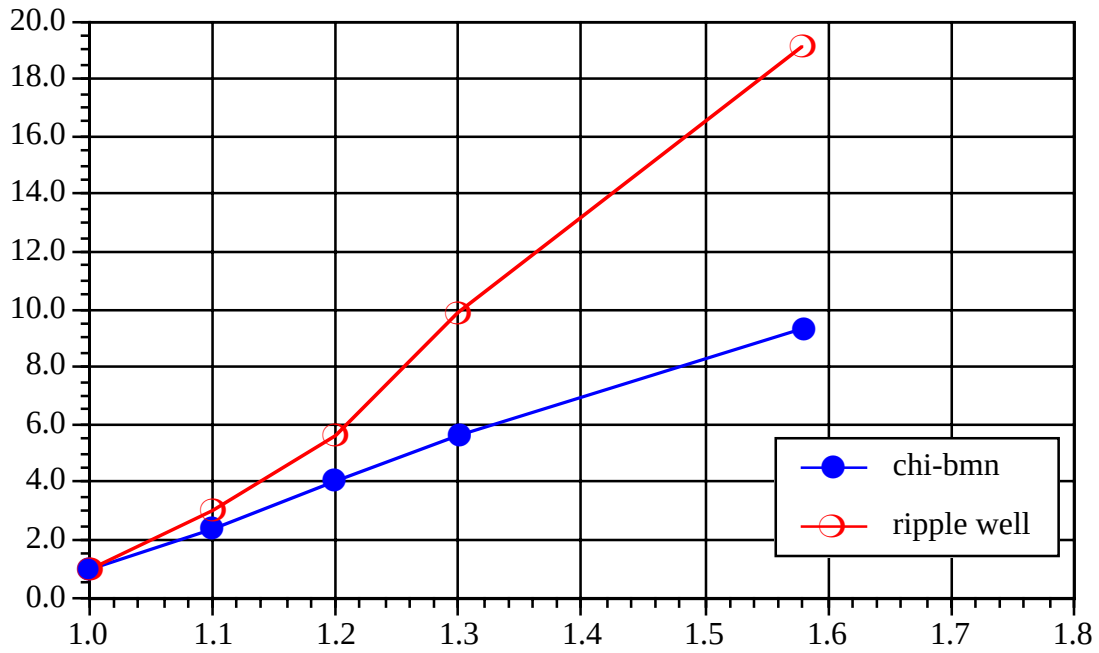
Stability Margin Improvement Due to Increased Elongation

- Both kink and ballooning stability have a lowest growth rate when κ is increased by 20% (relative to that of C82). As the elongation is increased further, the loss of magnetic shear and the decrease in iota tend to de-stabilize the kink and ballooning.



Loss of QA As Elongation Increases

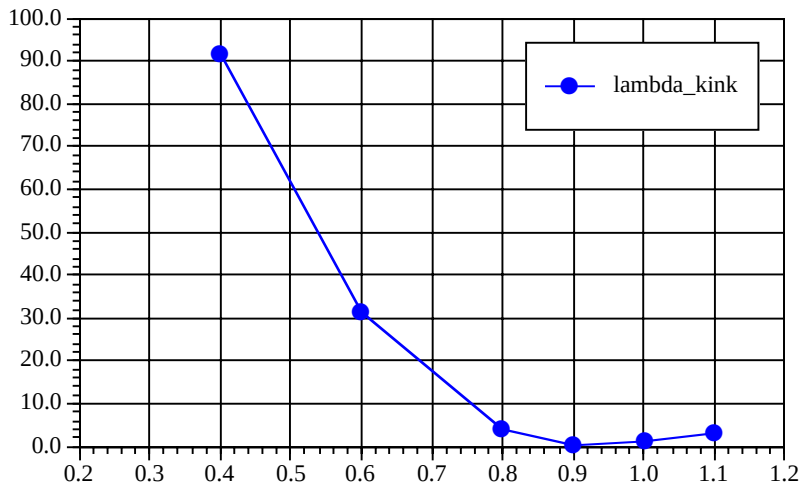
- Increasing elongation introduces (m,n)= (0,1), (1,1) and (1,-1) components in the Bmn spectrum. The mirror term causes the ripple well area to increase significantly. To re-symmetrize the Bmn without damaging kink and ballooning needs considerable efforts.

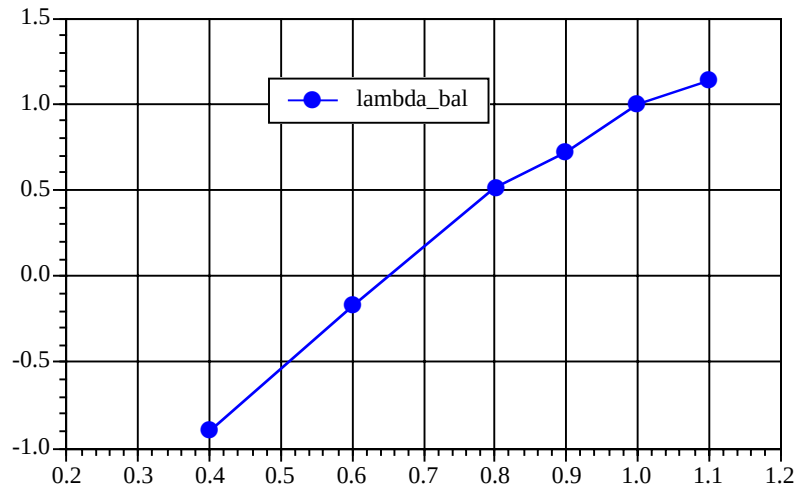


S=0.5

Stability Margin versus Triangularity

- We also examined the effects of triangularity (δ) at $\kappa/\kappa(c82)\sim1.2$ by varying R(2,0). For $\delta/\delta(c82)<0.9$, the ballooning continue to improve at smaller values of δ, but at the expense of worsening kink stability. At $\delta/\delta(c82)=0.9$ the kink stability has a minimum growth rate.





Modification of C82 to Realize a Higher Critical β with Increased Elongation

- Increasing Z(1,0), without modifying other terms, does not lead to an increase in stability beta.

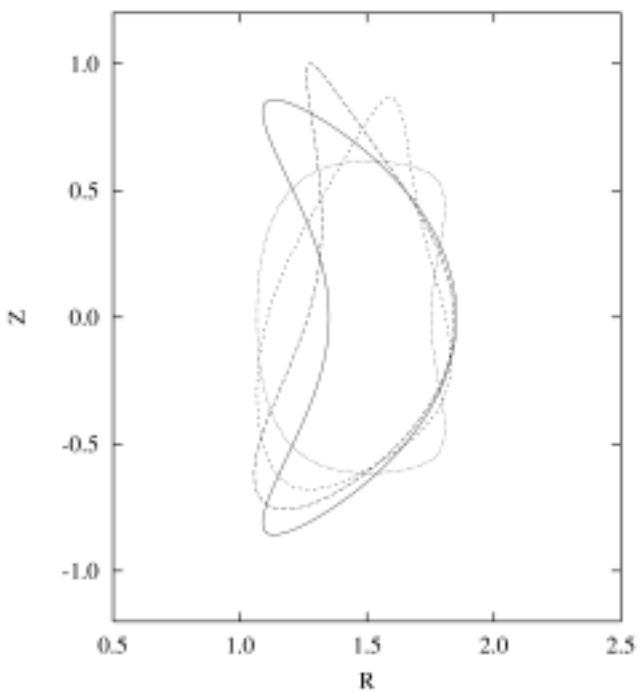
- But, by increasing R(2,1) (a *l*=3 component) simultaneously, we were able to increase the critical β approximately in proportion to the increase in elongation up to κ~2.7.

- We illustrate an example, with κ/κ(C82)=1.3, or κ~2.5.

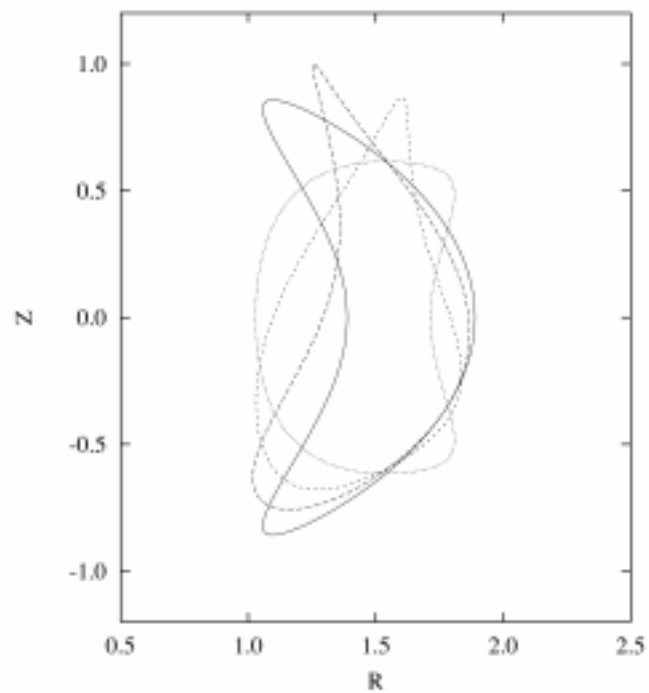
- The main issue is whether such stable configurations which presently are not quasi-axisymmetric can be made to be QA.

Comparison of Boundary Shape

Z(1,0) modified

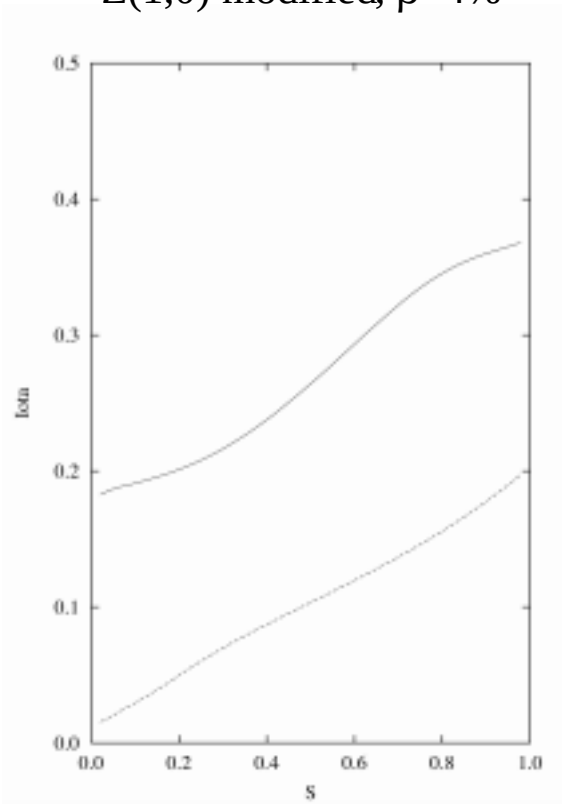


Z(1,0) and R(2,1) modified

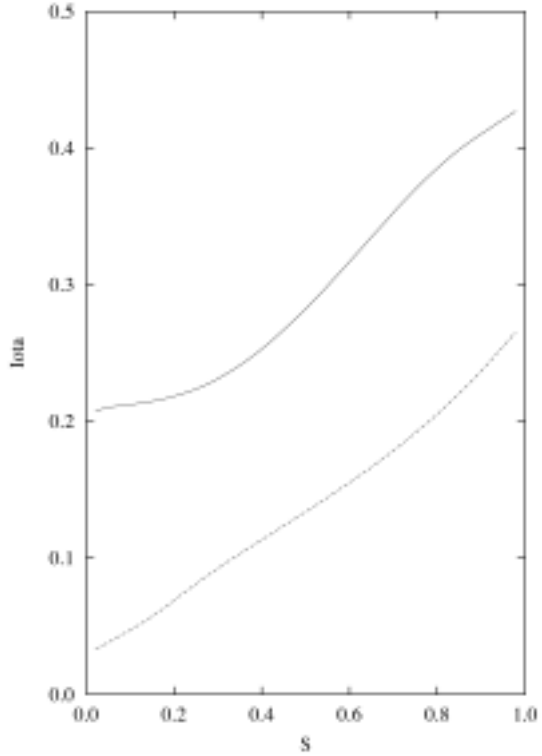


Comparison of Iota Profile

Z(1,0) modified, β=4%

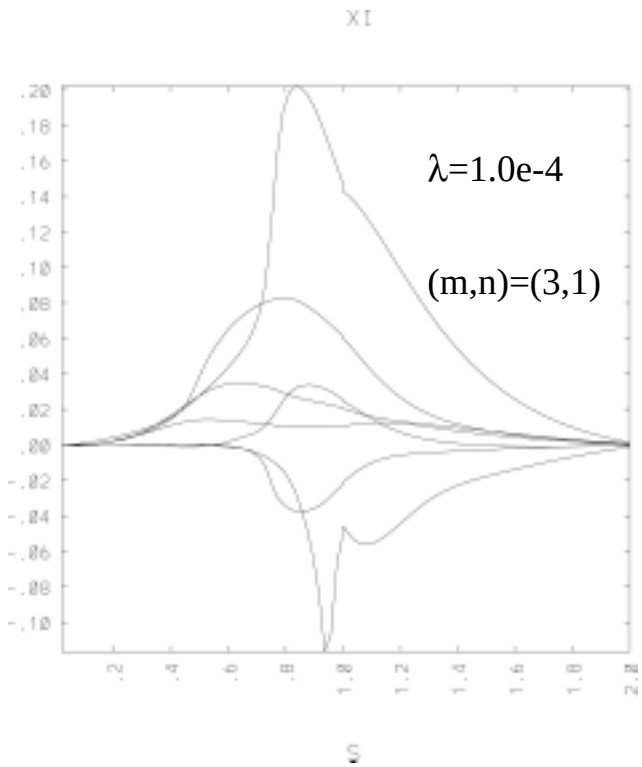


Z(1,0) and R(2,1) modified, β=5.35%

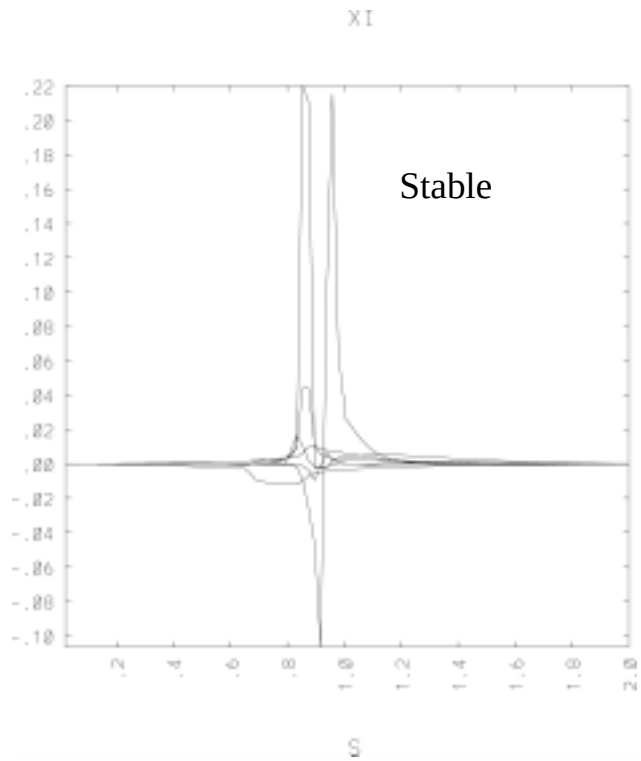


Comparison of Kink Stability

Z(1,0) modified, β=4%

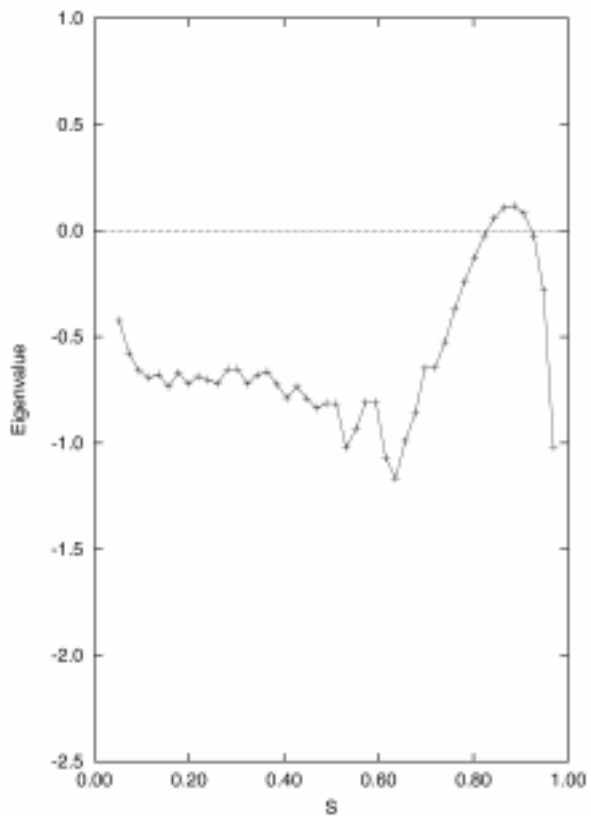


Z(1,0)+R(2,1) modified, β=5.35%

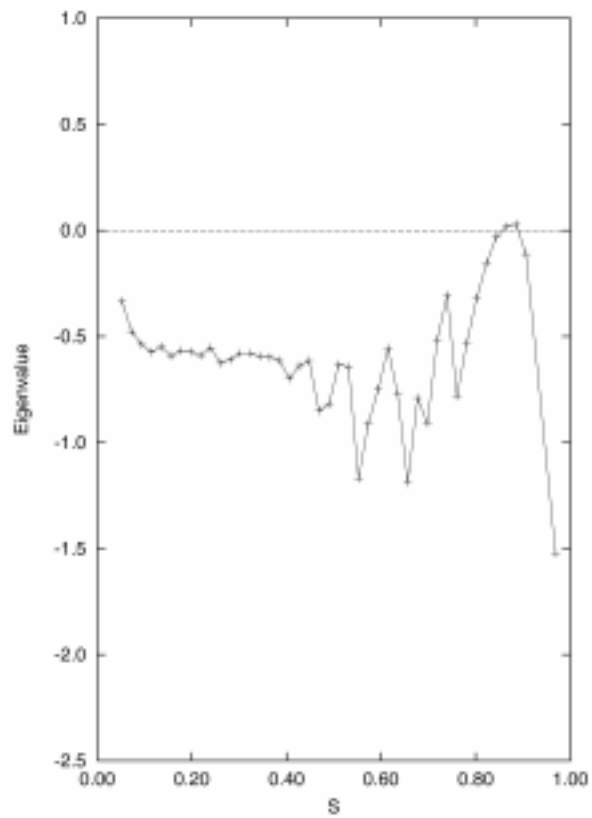


Comparison of Ballooning Stability

Z(1,0) modified. β=4%



Z(1,0)+R(2,1) modified, β=5.35%



Both Cases Are Not Quasi-Axisymmetric

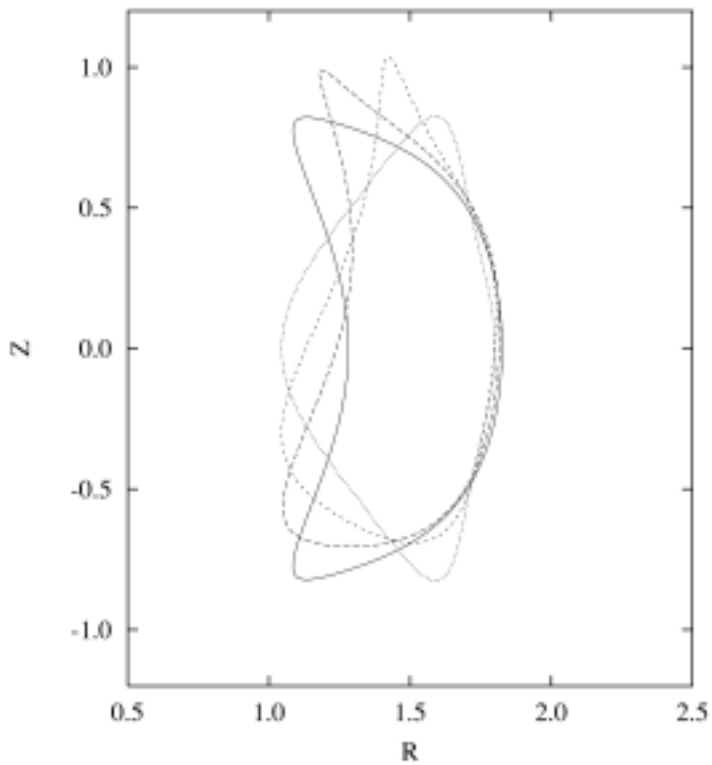
	Z(1,0) modified	Z(1,0)+R(2,1) modified
B(1,1,s=0.5)/B(0,0,s=0)	3.3%	8.1%
B(1,-1,s=0.5)/B(0,0,s=0)	2.1%	6.1%
B(0,1,s=0.5)/B(0,0,s=0)	6.0%	7.6%
B(2,1,s=0.5)/B(0,0,s=0)	0.7%	2.7%
χ^2 (s=0.3)	4.6e-3	1.1e-2
χ^2 (s=0.5)	5.7e-3 (1.5e-4 for C82)	1.9e-2

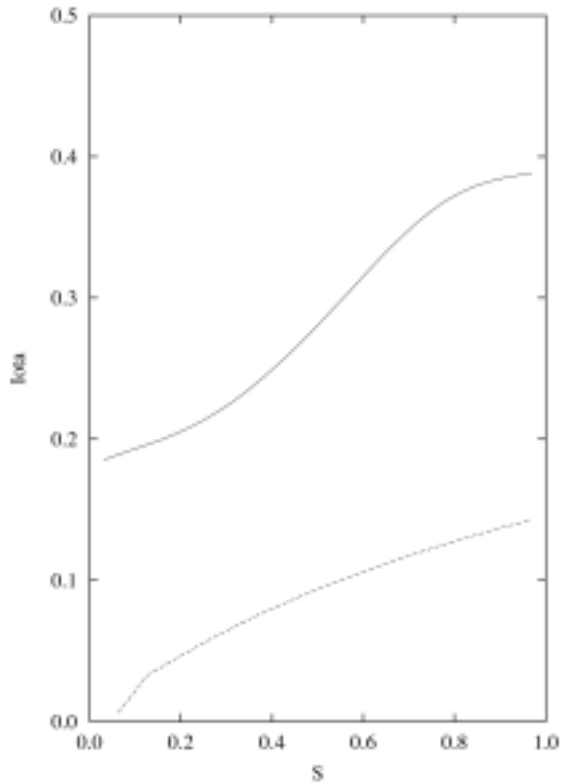
Initial Results of Searching for a QAS with Higher Elongation

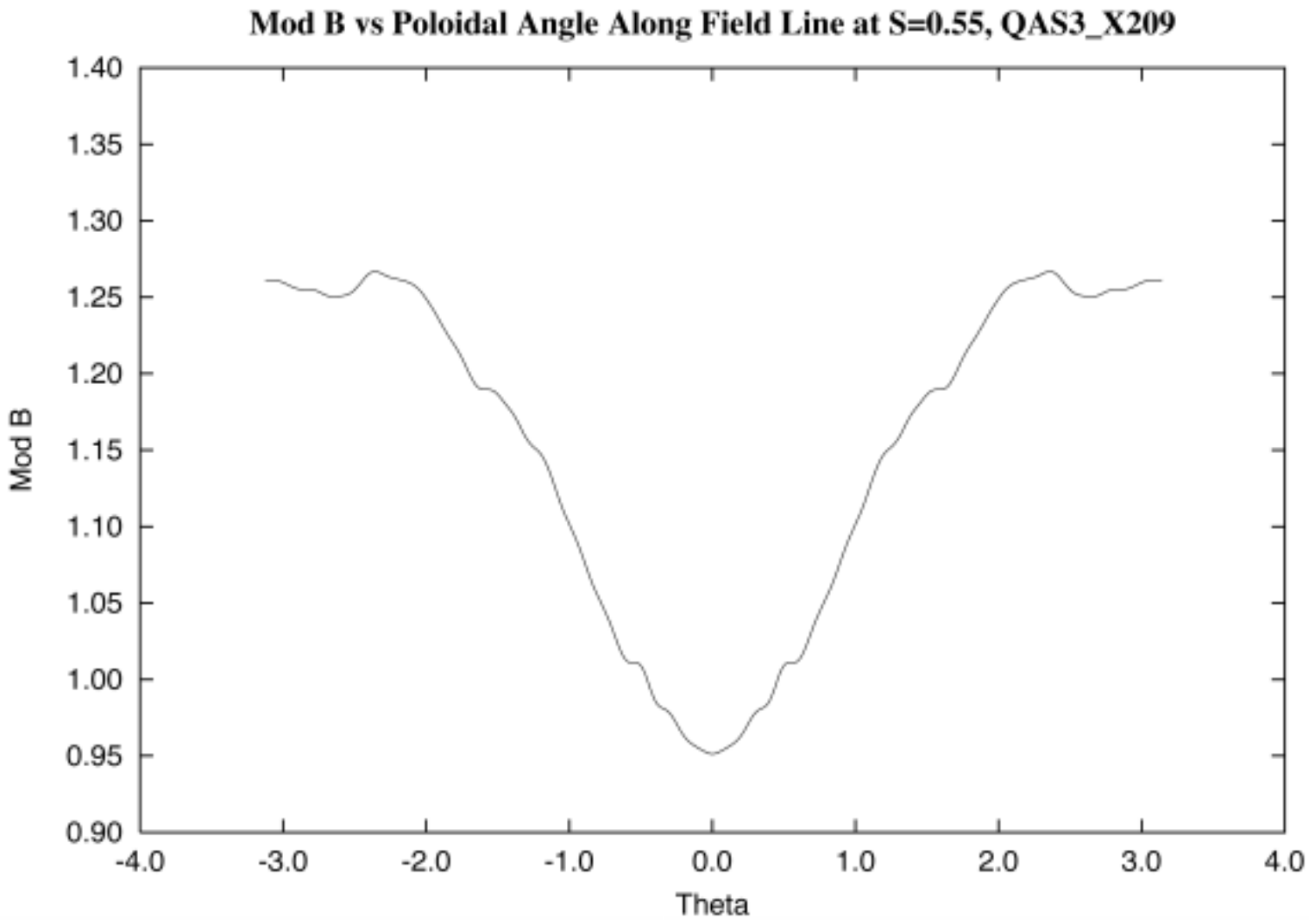
- Starting from a modified C82, with elongation 2.7 and β~6%, discussed above, the optimizer has, so far, not been able to find a path that reduces the Bmns without significantly affecting the kink stability.

- As an alternative, we have begun to search for a QA configuration starting from a tokamak (κ~2.5, ballooning beta~8.5%). A configuration with excellent QA has been obtained (see the illustration). We are now trying to stabilize the kinks.

QAS_X209


1.0
0.5
0.0
-0.5
-1.0
Z
0.5
1.0
1.5
2.0
2.5
R


0.5
0.4
0.3
0.2
0.1
0.0
keta
0.0
0.2
0.4
0.6
0.8
1.0
s


Mod B vs Poloidal Angle Along Field Line at S=0.55, QAS3_X209
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
Mod B
-4.0
-3.0
-2.0
-1.0
0.0
1.0
2.0
3.0
4.0
Theta