NSTX

JP1.85

Impact of Edge Plasma Shaping on Kink Modes in NSTX[1]

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This poster is available online at
http://w3.pppl.gov/manickam/

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Abstract

Recent studies, [Manickam et al. EPS Conference, Maastricht 1999] have shown that there is an opportunity to increase the β -threshold for external kink modes in NSTX. Specifically, analysis that includes consideration of the plasma in the vicinity of the separatrix has shown that the threshold-β for the external kink mode may be increased by upto 25%. The cause of this increase has been identified as the result of two effects. The first is the increase in the safety-factor at the plasma edge, and the second is the increased shear stabilization. We investigate these stabiling mechanisms for NSTX. We consider achievable free-boundary equilibria within the context of the coil configurations on the device and we also consider a variety of profiles.

Equilibrium Profiles

EQUILIBRIUM

- NSTX geometry
- EFIT equilibrium - $\Psi(x, z)$ - free boundary equilibrium
- Toroidal field: B=0.3 $Tesla$ at 0.85 m
- Plasma current = 1.0 MA
- Profiles

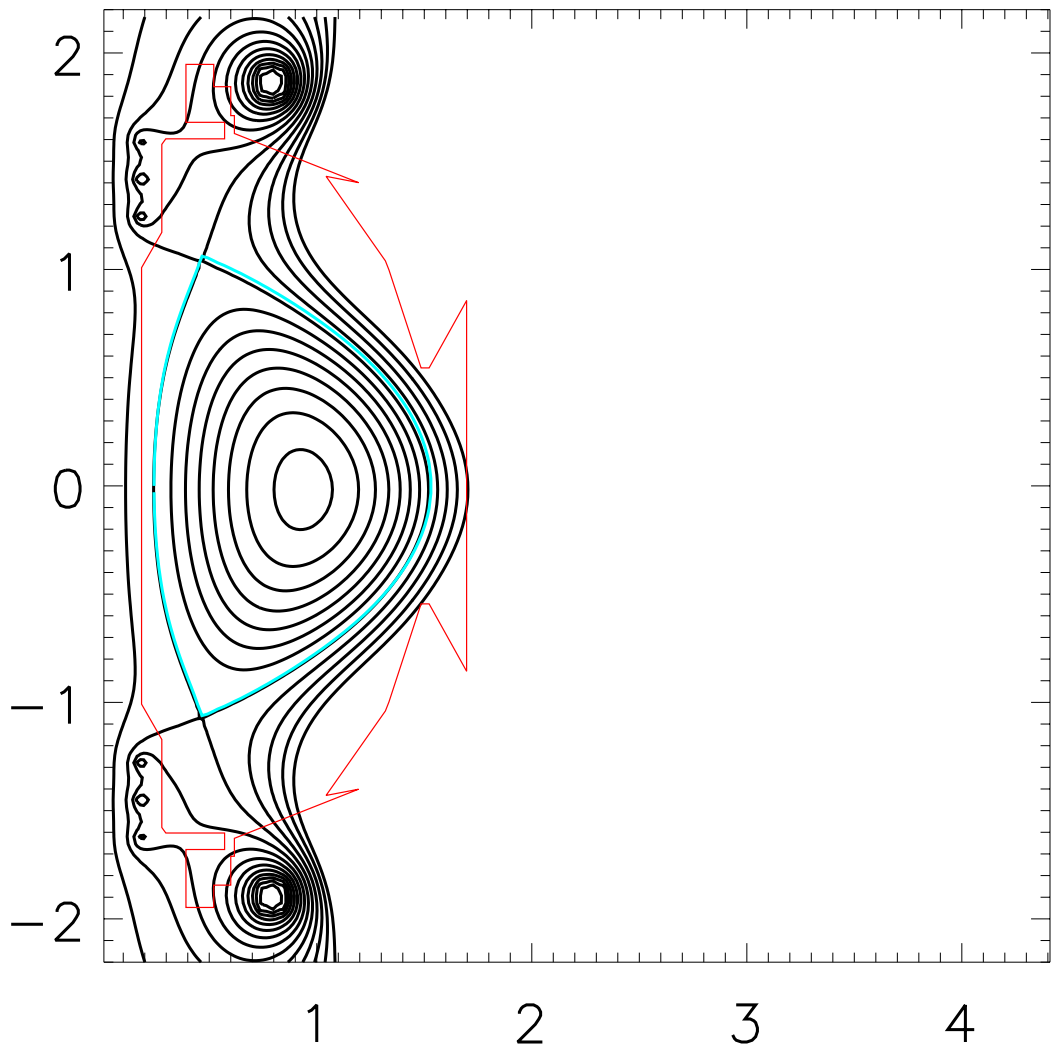
  Pressure

  $$p = p_0(1 - \psi^3)^2$$

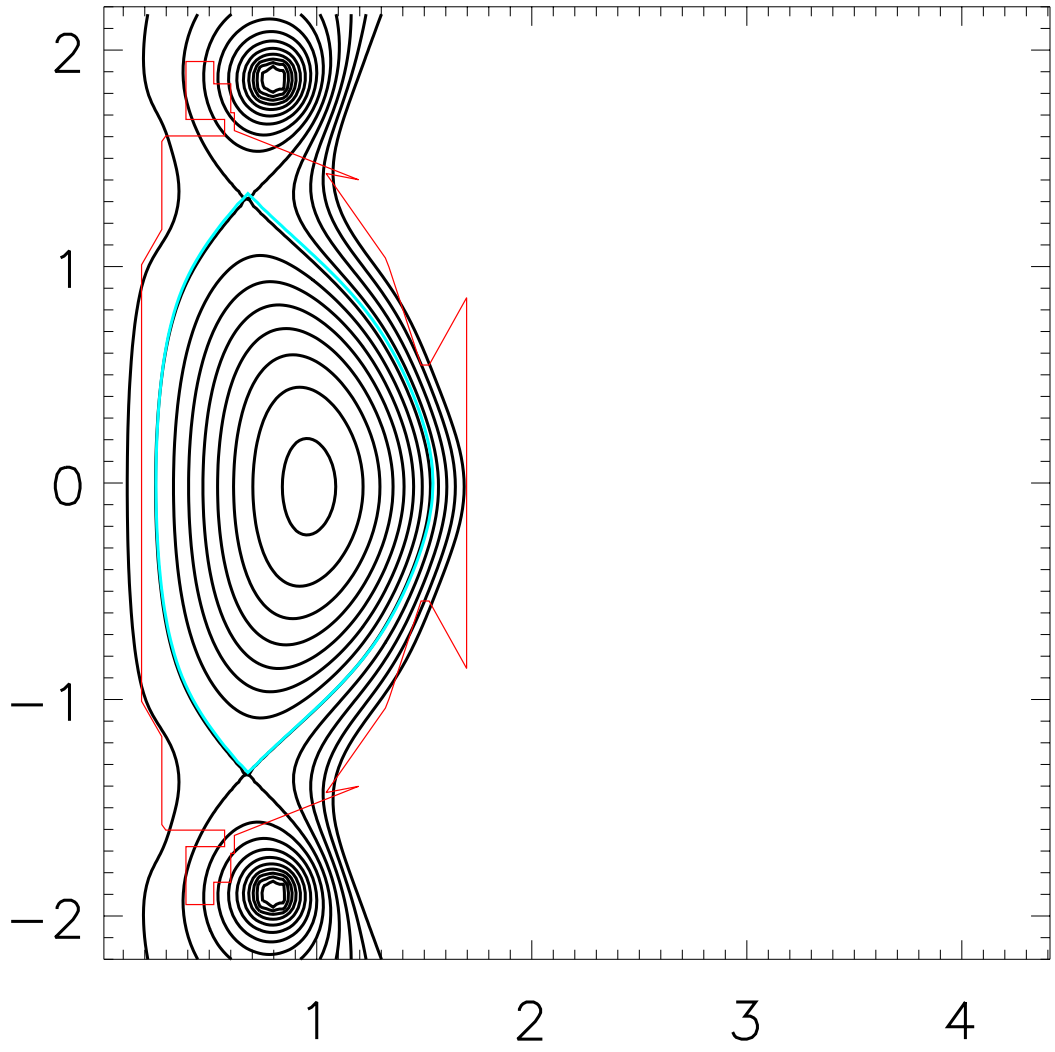
  ff'

  $$ff' = 1.505\psi^5 - 2.846\psi^4 + 2.387\psi^3 - 2.926\psi^2 + 0.874\psi + 1.0.$$

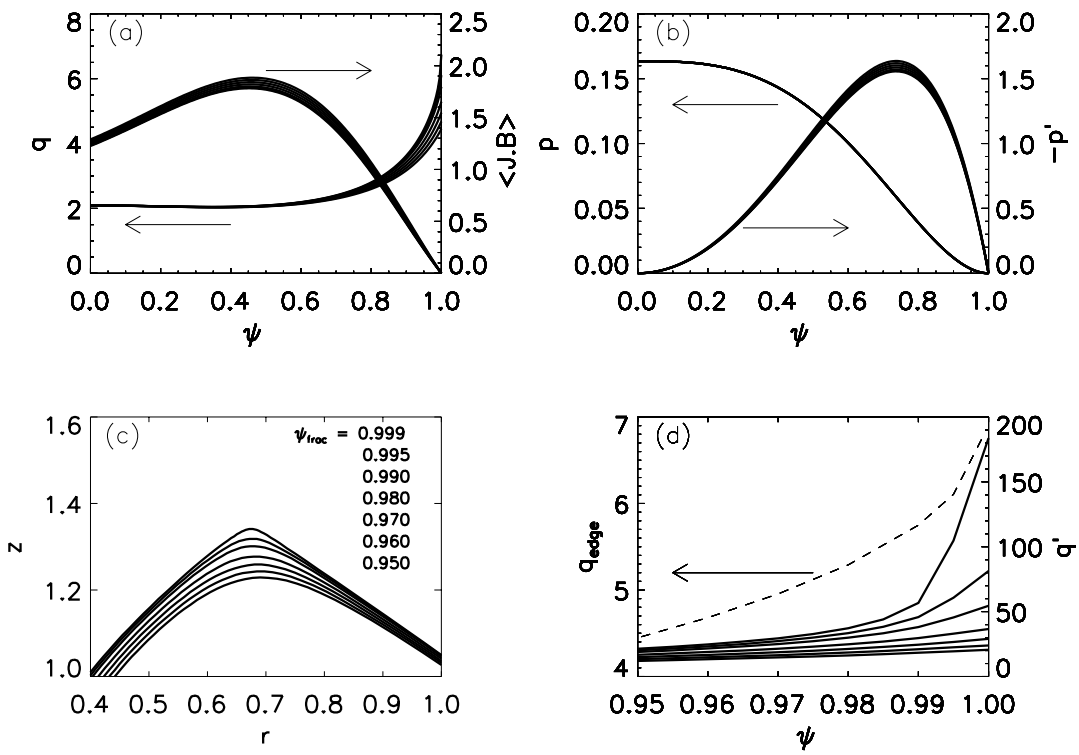
Elongation = 1.6



Elongation = 2.0



EQUILIBRIUM PROFILES for Several $\psi/\psi_{\mathrm{frac}}$ values

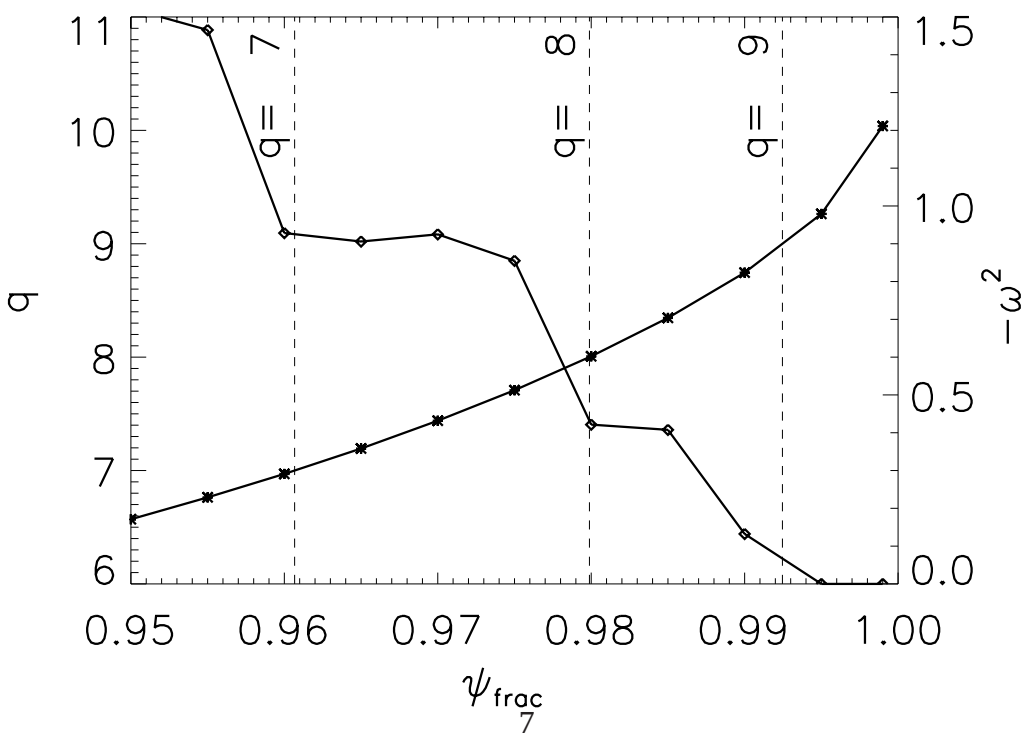


Stability Analysis

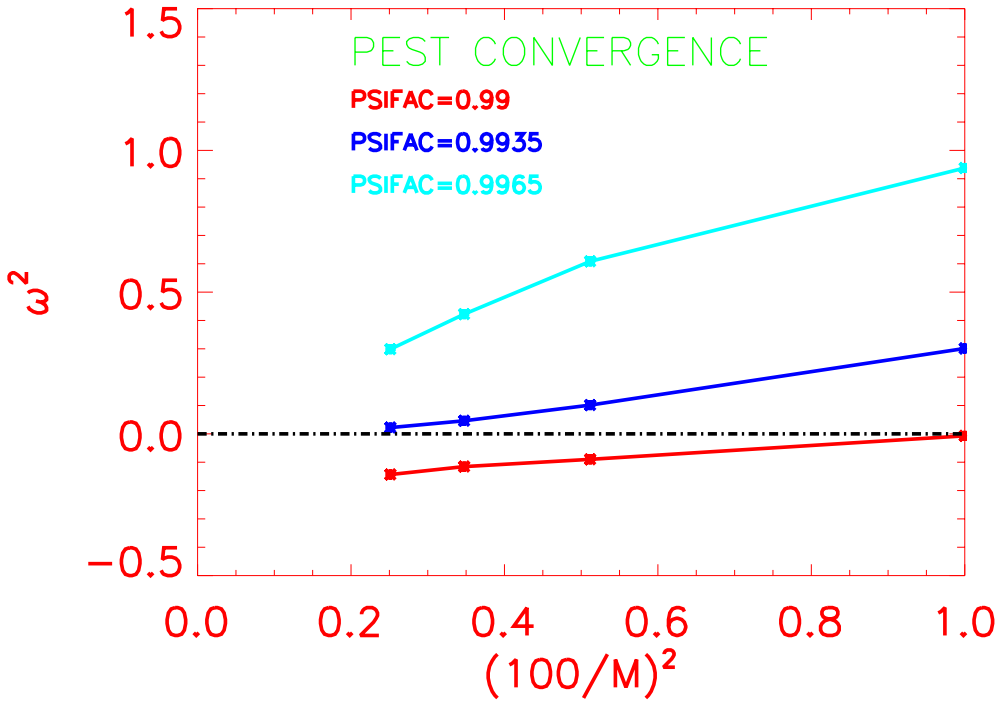
Increasing $\psi/\psi_{\rm frac}$ reduces the growth-rate

There are jumps when $q_{\rm edge}$ crosses an integer value

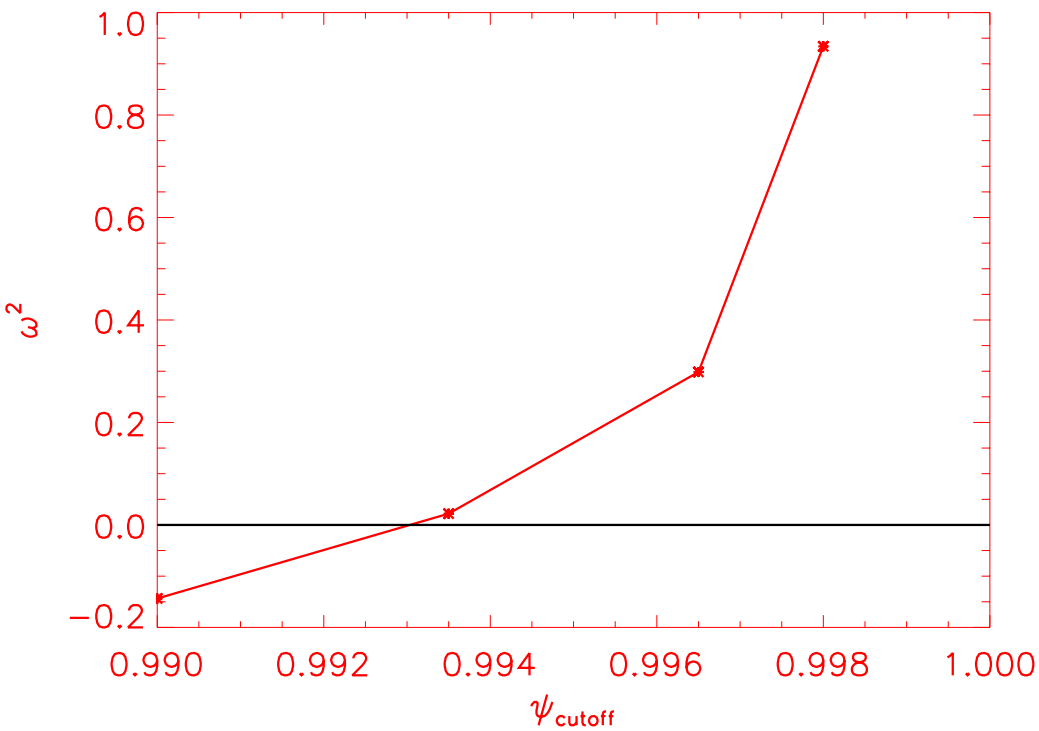
Complete stability is obtained when $\psi/\psi_{\rm frac}$ ~0.993



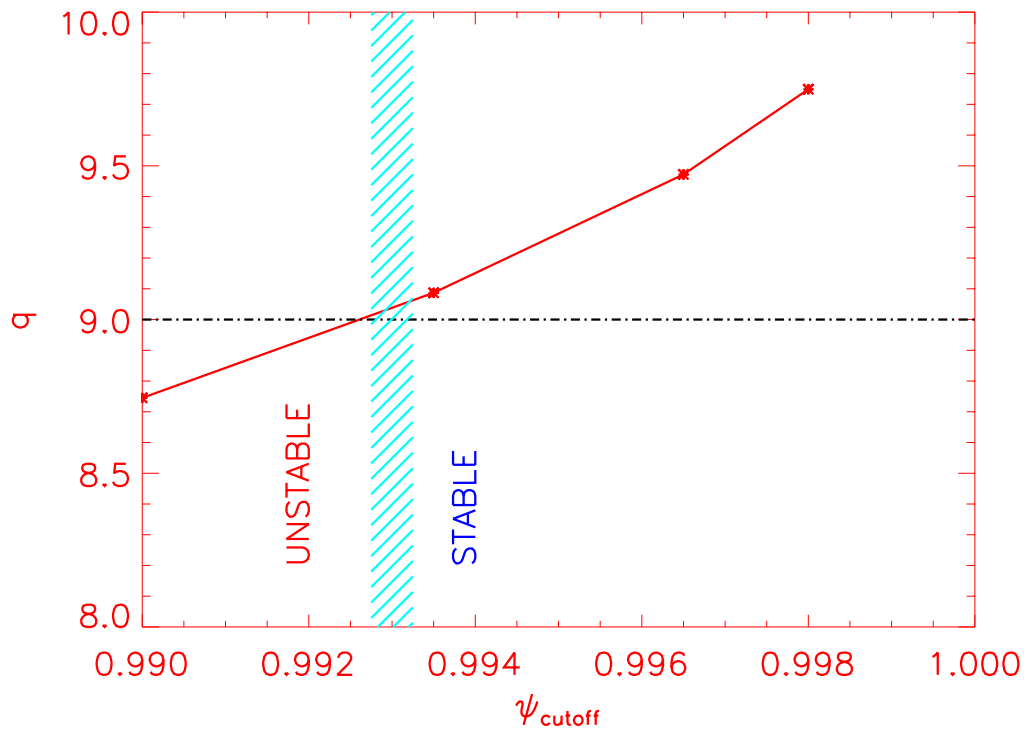
Convergence study with PEST



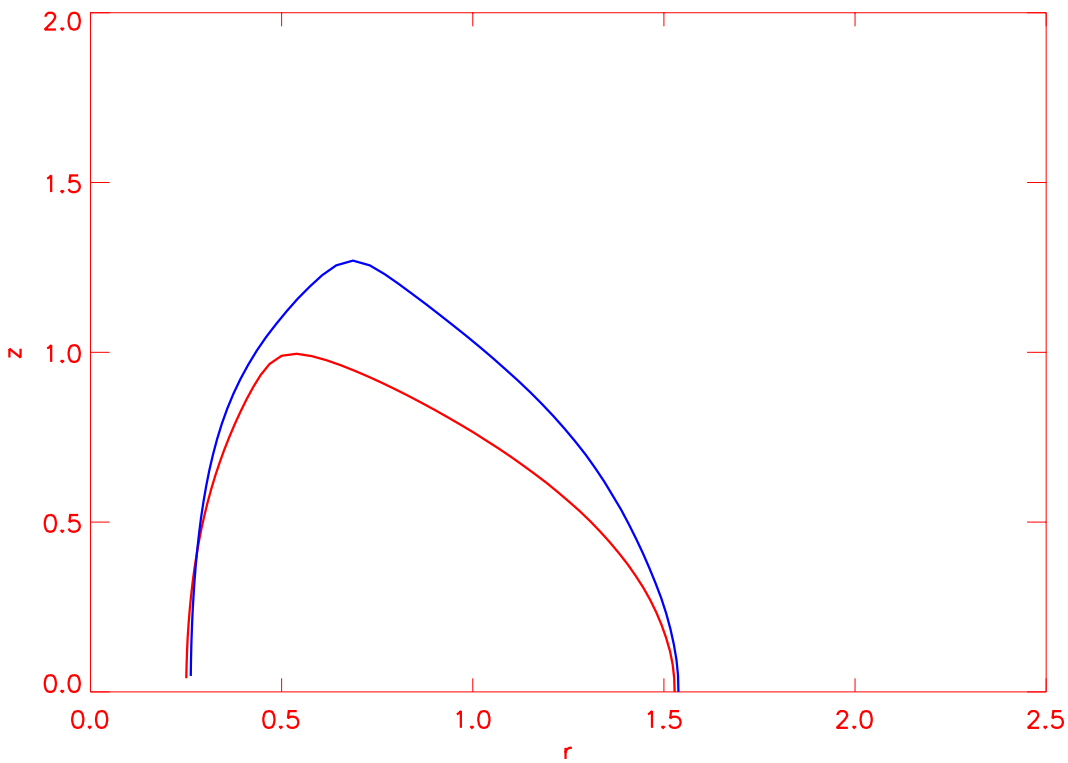
Marginal stability at $\psi/\psi_{\mathrm{frac}}$ ~0.93



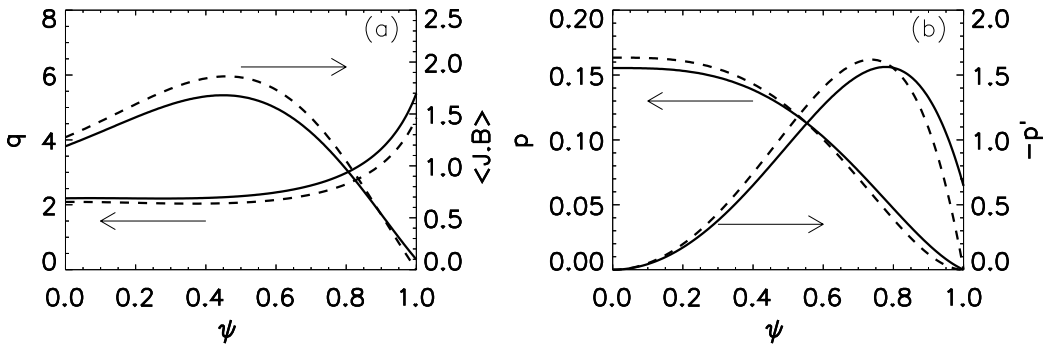
Marginal stability corresponds to $q_{\mathrm{edge}} > 9.0$



$\psi/\psi_{\mathrm{frac}}$ =0.99 flux-surface for the two geometries studied



H-mode(solid) and L-mode(broken) profiles



Stability limits for $\kappa = 1.6$

- Note the increase when ψ/ψ_{sep} is increased from 0.96 to 0.99
- The relative increase is greater for the L-mode profile than the H-mode profile
- There is some sensitivity to q_{axis} and q_{edge}

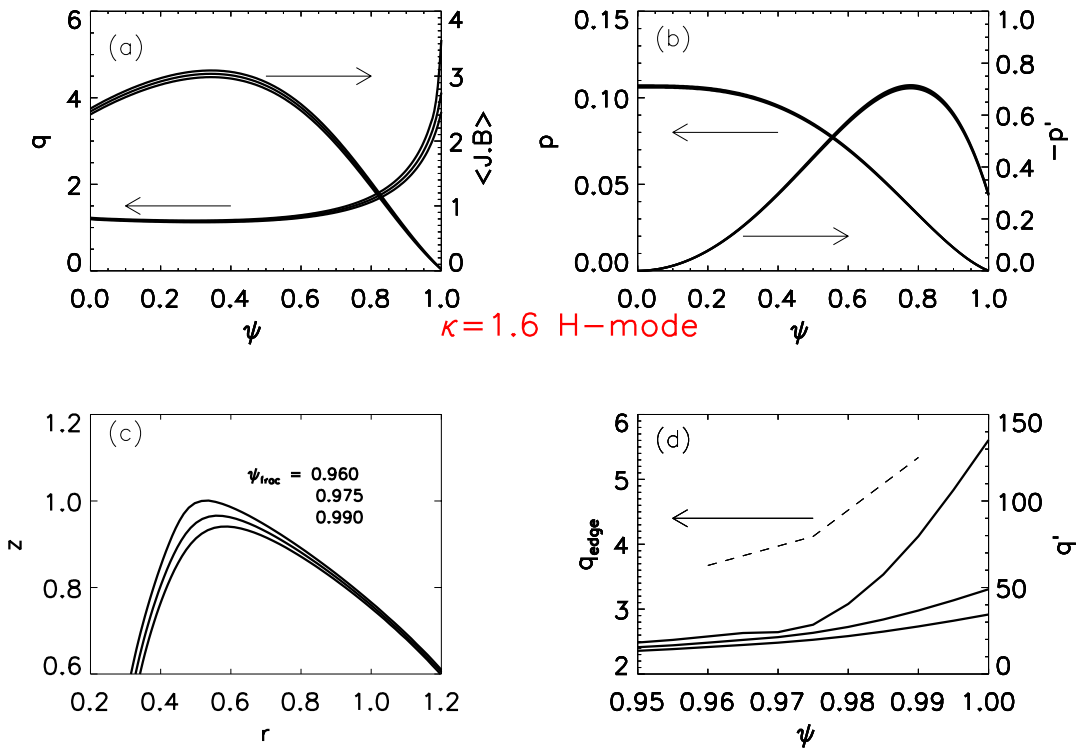
κ=1.6 L-mode

ψ/ψ_{sep}	q_{axis}	q_{min}	q_{edge}	β	β_N
0.96	1.166	1.090	3.663	14.4	2.82
0.99	1.200	1.130	5.339	26.17	4.99

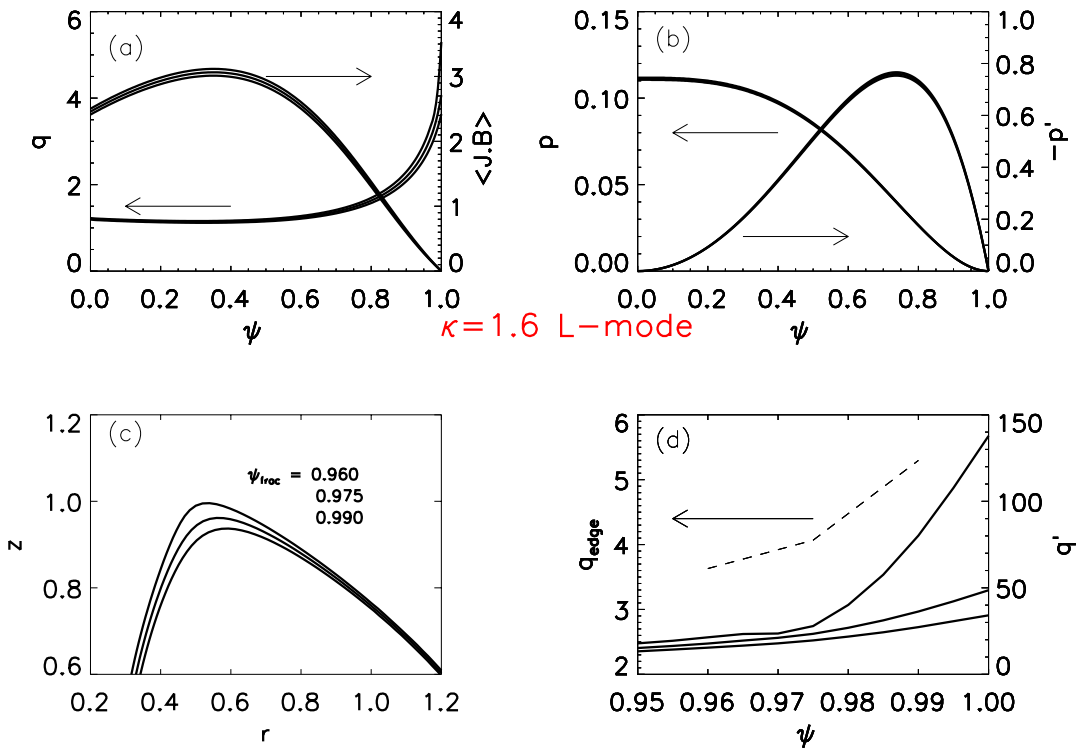
κ=1.6 H-mode

ψ/ψ_{sep}	q_{axis}	q_{min}	q_{edge}	β	β_N
0.96	1.168	1.096	3.705	14.97	2.93
0.99	1.203	1.136	5.350	19.94	3.84

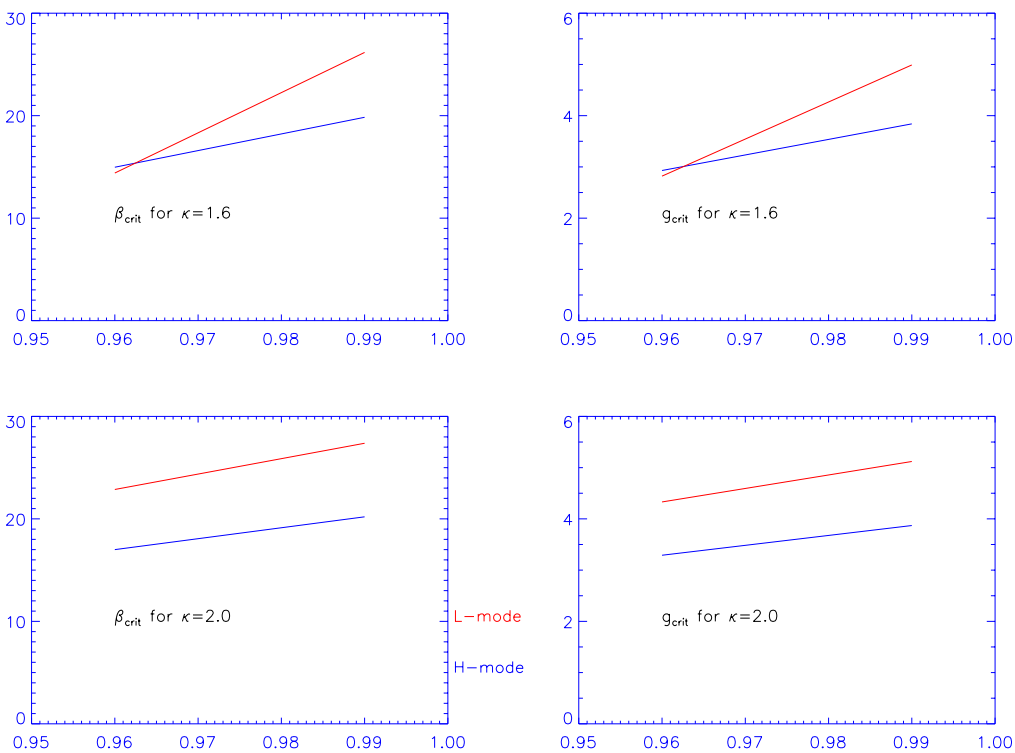
H-mode profiles for $\kappa = 1.6$



L-mode profiles for $\kappa = 1.6$



Marginal β and Troyon factor g dependence



Stability limits for $\kappa = 1.6$

- Note the increase when ψ/ψ_{sep} is increased from 0.96 to 0.99
- The relative increase in the L-mode case is smaller than for the $\kappa = 1.6$ equilibria
- There is less sensitivity to q_{axis} and q_{edge} than in the $\kappa = 1.6$ case. This is due to the increase in q_{axis} from 1.1 to 1.4

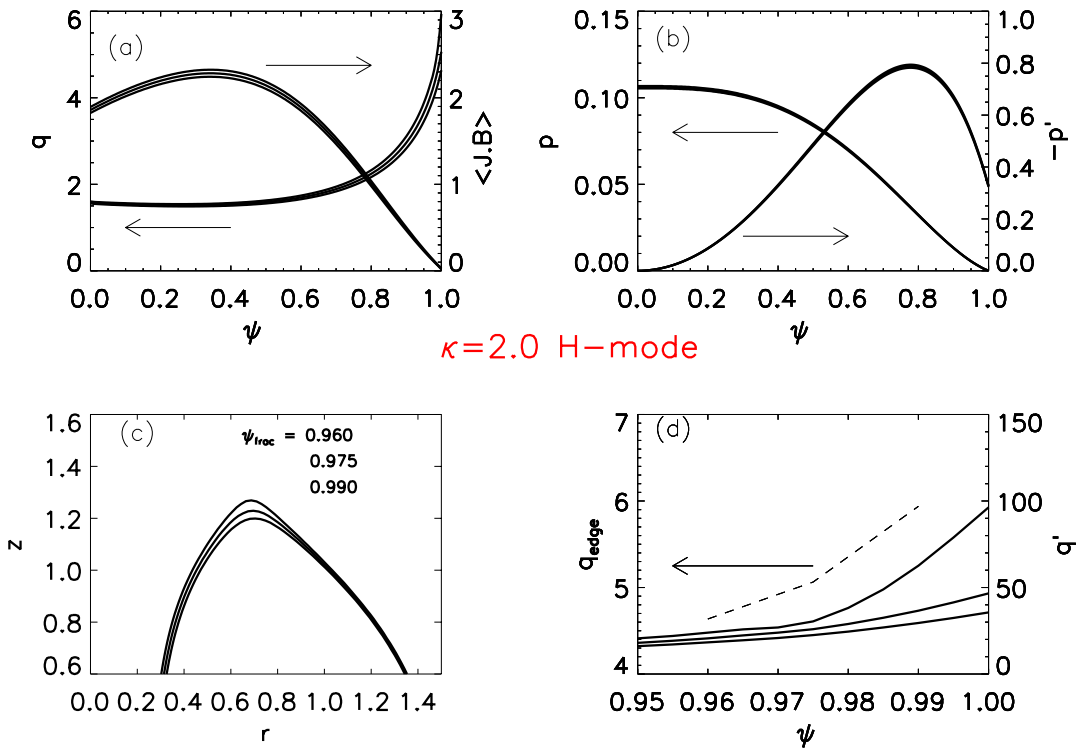
κ=2 L-mode

ψ/ψ_{sep}	q_{axis}	q_{min}	q_{edge}	β	β_N
0.96	1.496	1.417	4.398	22.87	4.33
0.99	1.541	1.468	5.619	27.38	5.12

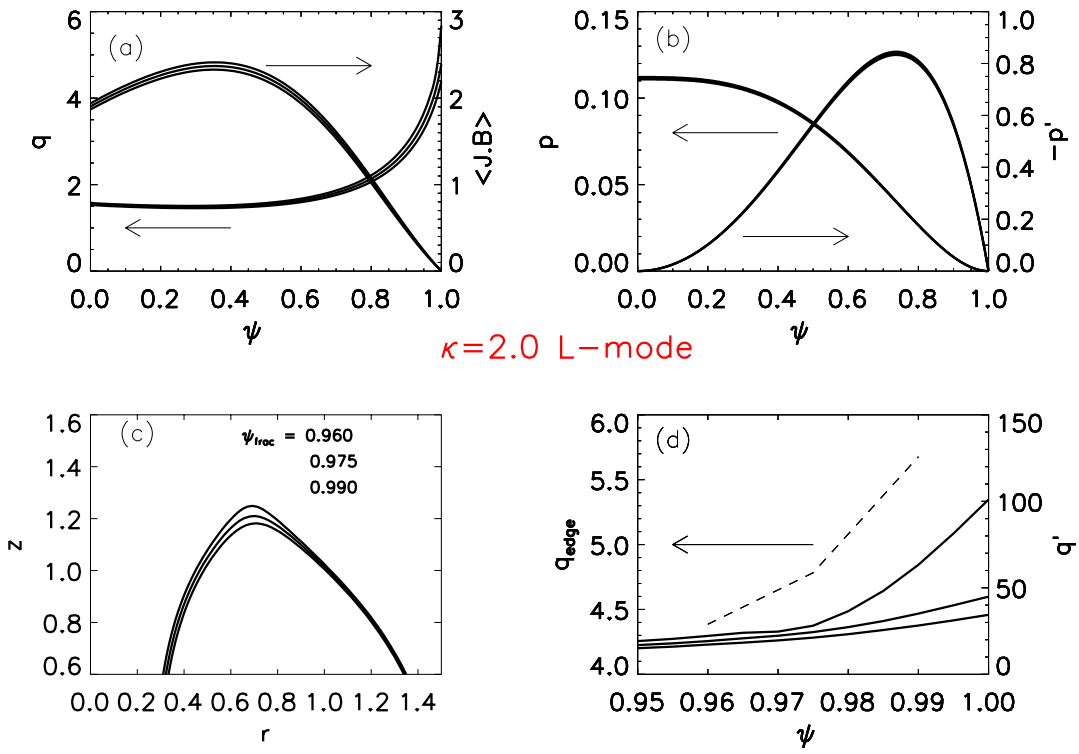
κ=2 H-mode

ψ/ψ_{sep}	q_{axis}	q_{min}	q_{edge}	β	β_N
0.96	1.520	1.451	4.651	17.00	3.29
0.99	1.565	1.503	5.852	20.20	3.87

H-mode profiles for $\kappa = 2$



L-mode profiles for $\kappa = 2$



Discussion.

• In this study we have to attempted to understand the role of the different features of a diverted plasma on the external kink instability.

• In order to do this we have carefully selected profiles which will highlight the role of the seperatrix. In order to minimize the role of internal modes, we have set $q_{\rm axis}$ greater than unity and adjusted the pressure gradient to be small in the core.

• The two important features of a diverted plasma are, the rapid rise in the safety-factor as the seperatrix is approached and the change in the local curvature, these are inter-related effects.

• We observe that while q rises rapidly, q' increases even more rapidly for this particular geometry, $\kappa = 2$, as we approach the seperatrix. The effect of this large value of q' is to dramatically improve the stability of the $n = 1$ external kink to raise the β threshold for the n=1 external kink to 28% and a Troyon coefficient β_N =5.5 when $\psi/\psi_{\rm sep}$ =0.993

• In order to understand the relative role of different plasma features we examine the stability for two geometries with L-mode and H-mode pressure profiles. The current profile shape is kept constant. We determine the β limits for $\psi/\psi_{\rm sep}$ =0.96 and 0.99

Discussion (contd.)

• It is interesting to note that even though, the pressure and current profile shapes were kept the same, with a different geometry, $\kappa = 1.6$, $\delta = 0.5$, compared with $\kappa = 2.0$, $\delta = 0.35$, the value of the shear, q', near the seperatrix increases by 50%.

• In spite of this, the β limits for a fixed pressure profile is the same in the two geometries, when $\psi/\psi_{\rm sep}$ =0.99.

• The other noteworthy feature is the strong role of the pressure gradient near the plasma edge in setting the β -limit. The L-mode profiles have significantly higher stable β compared with the H-mode profiles.

• The other interesting feature is the rather dramatic sensitivity to the value of $q_{\rm edge}$. In fact a systematic study, not shown here, of this effect shows that there may be islands of stability associated with having $q_{\rm edge}$ equal to an integer value.

• This also reflects the experimental observations of increased MHD activity shortly after $q_{\rm edge}$ passes through an integer value. In passing we also note that these equilibria are stable to high-n ballooning modes.

• Further studies with different plasma profiles are needed to determine the best operating regimes for diverted plasmas.