

(1)

# Aspect Ratio / Elongation Studies

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5/16/00

- all aspect ratio and elongation variations assume
  - constant volume (same as C82)
  - constant  $B_p(R=\bar{R}) = 1.1T$  (same as C82)
  - bootstrap current constraint\*
  - $\langle s \rangle$  range similar to C82 ;  $i(a) < 0.5$
- previous analysis showed that for  $\chi=1.9$  (same as C82),  $\beta \sim 4\%$ , bootstrap consistent current magnitude, resulted in strong plasma shaping at  $A=4.5 \pm 5.5$

the coil complexity measure increased  
the higher "relative" current at higher aspect  
ratios is considered responsible for stronger shaping  
to restabilize the kink mode

- present work covers aspect ratio variation, at higher elongation  $\chi=2.45$ ,  $A=3.0-5.0$

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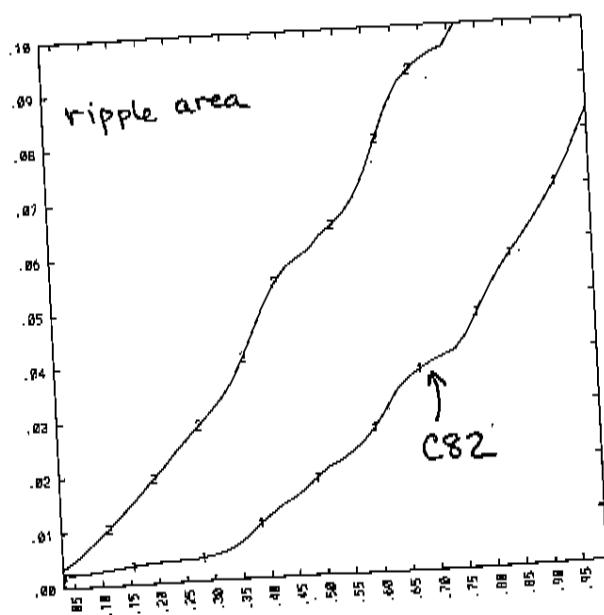
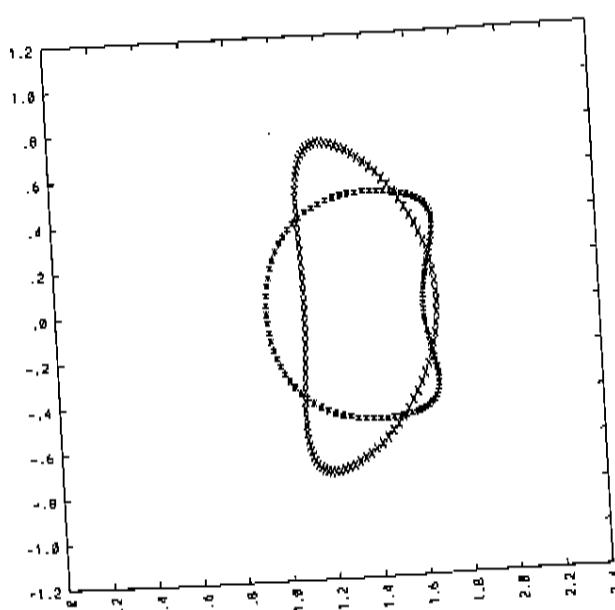
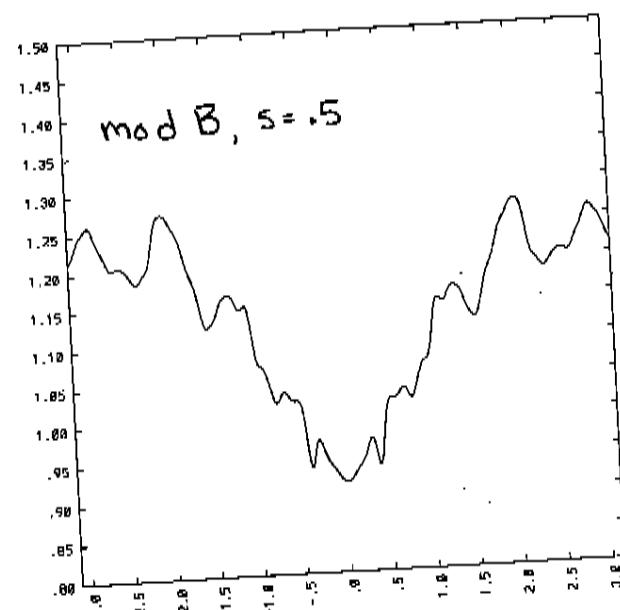
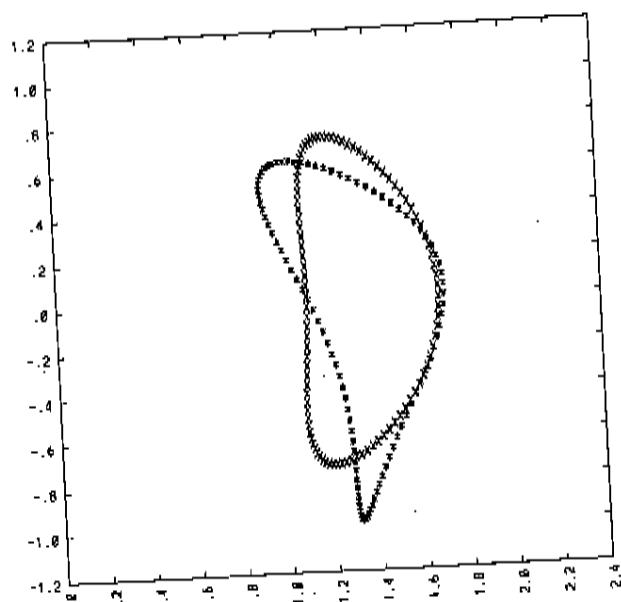
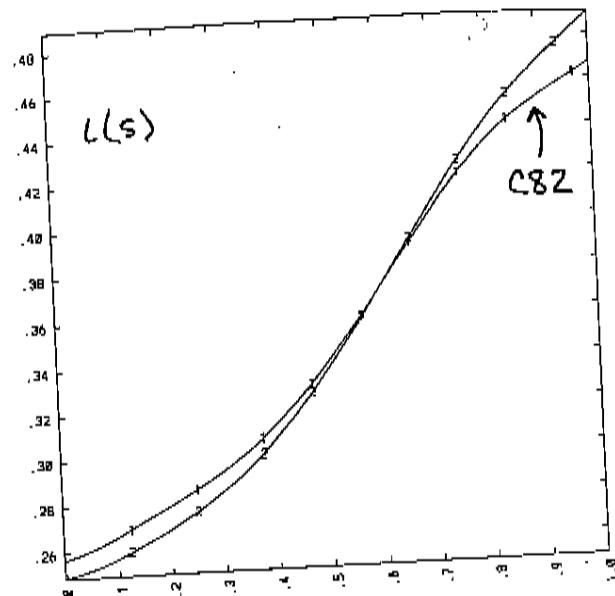
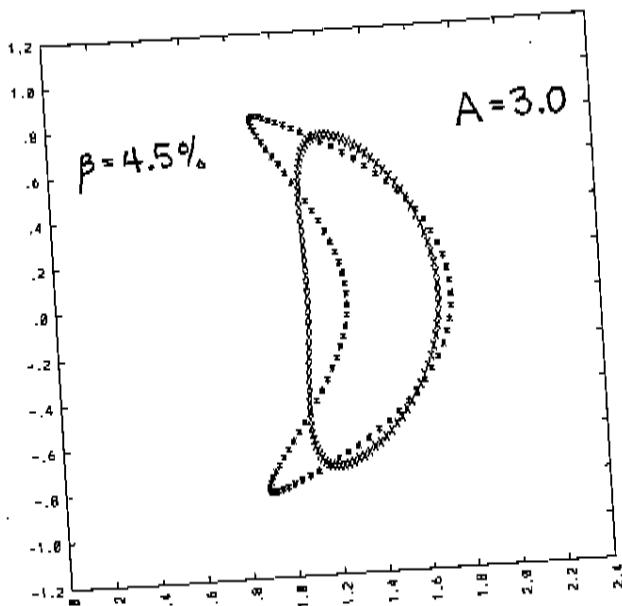
- bootstrap current calculation\*

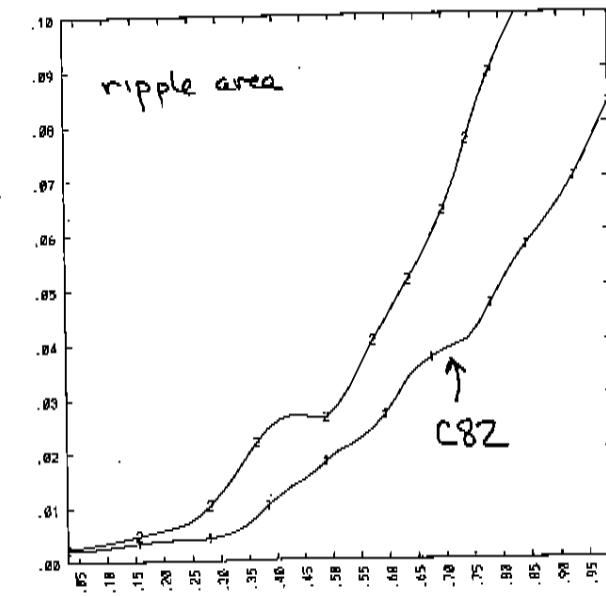
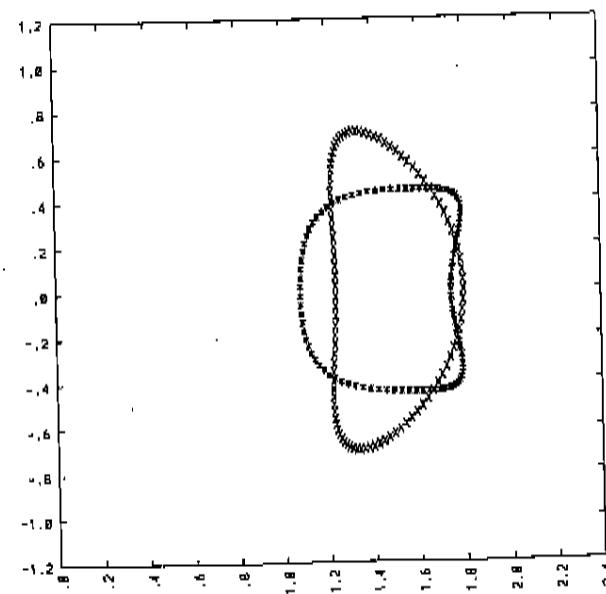
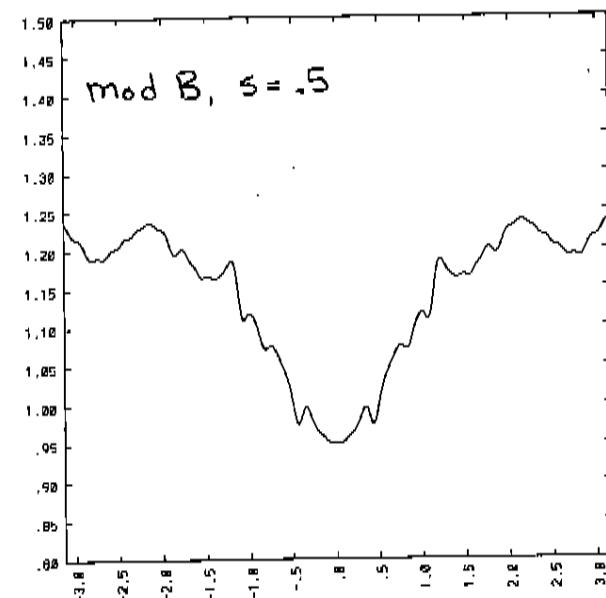
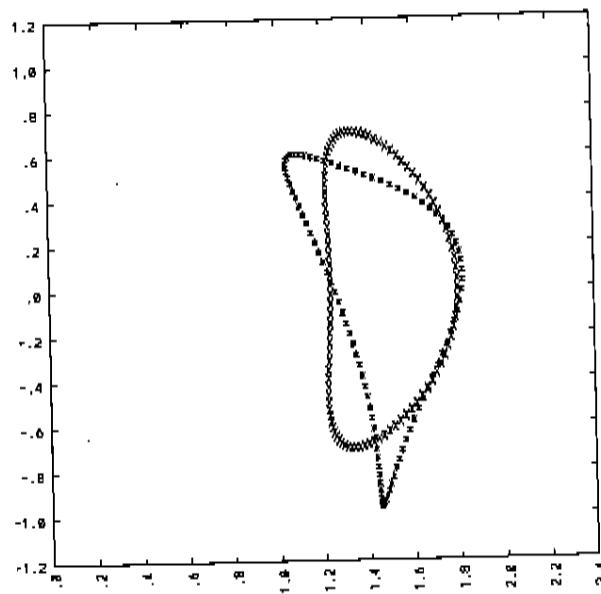
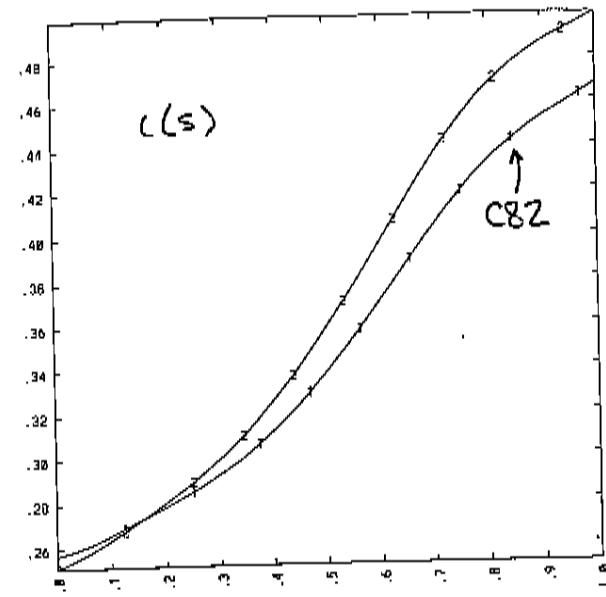
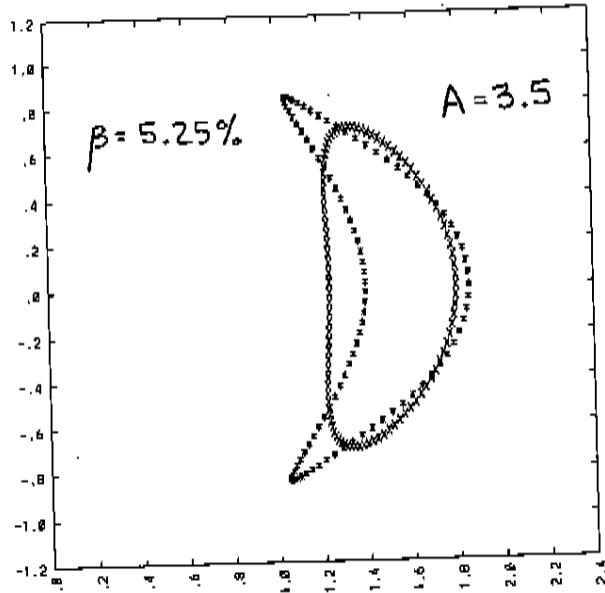
- use axisymmetric bootstrap formulation, Harris model which has collisional corrections to single ion collisionless formula
- using axisymmetric equilibrium calculation that includes prescribed current (to produce the correct total  $i$  profile) and bootstrap current self-consistently
- use C82 as benchmark
  - make  $\zeta(s)$  similar to C82
  - match 200kA for C82 with
$$\begin{aligned} T(0) &= 2 \text{ keV} \\ \frac{n(0)}{\langle n \rangle} &\approx 1.05 \end{aligned} \quad \left. \right\} \text{for } \beta \sim 4\%.$$
  - at higher  $\beta$  values scale  $T(0) \propto n(0)$  to approximately preserve  $\frac{nR}{T^2}$
- use previous assumptions
  - $B_p(R = \bar{R}) = 1.1 \text{ T}$
  - $\bar{R} \neq \bar{a}$  from VMEC

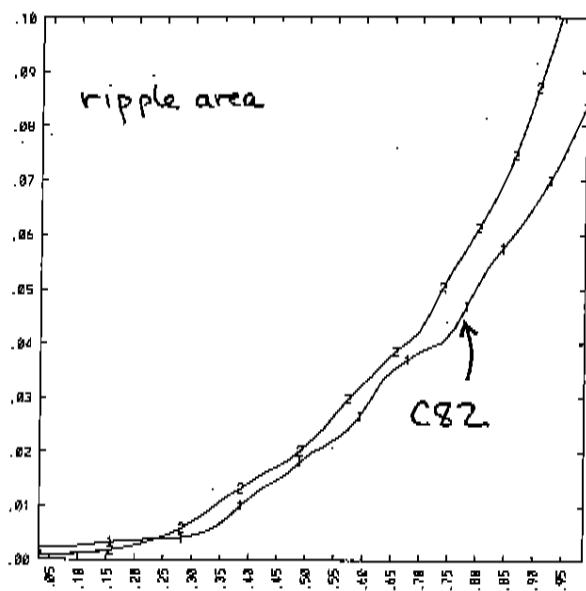
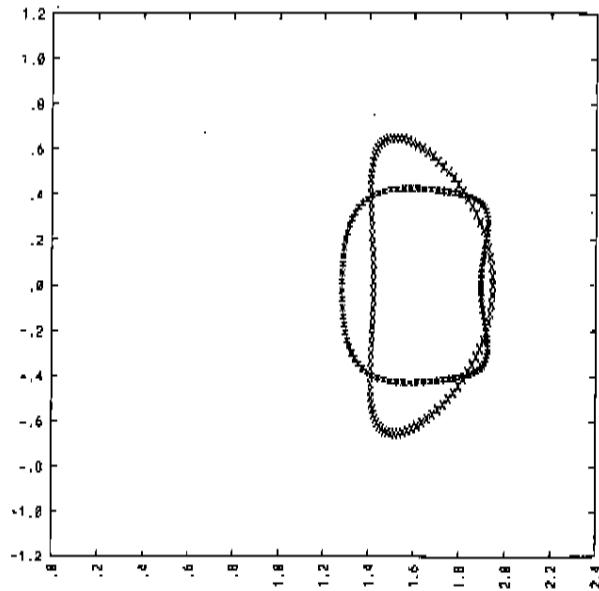
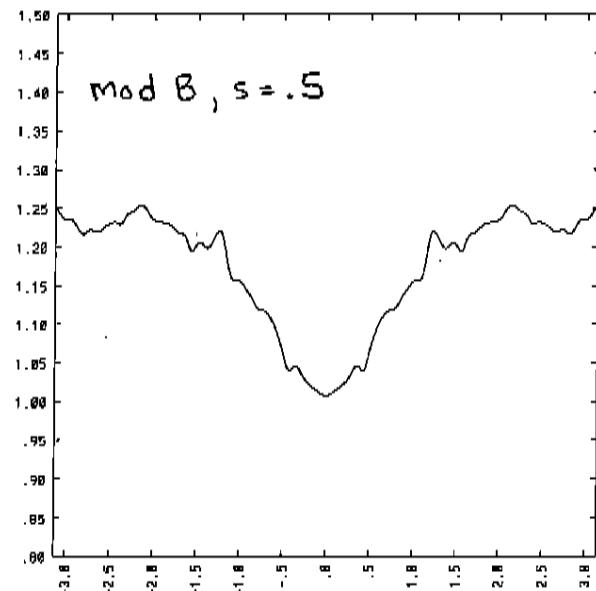
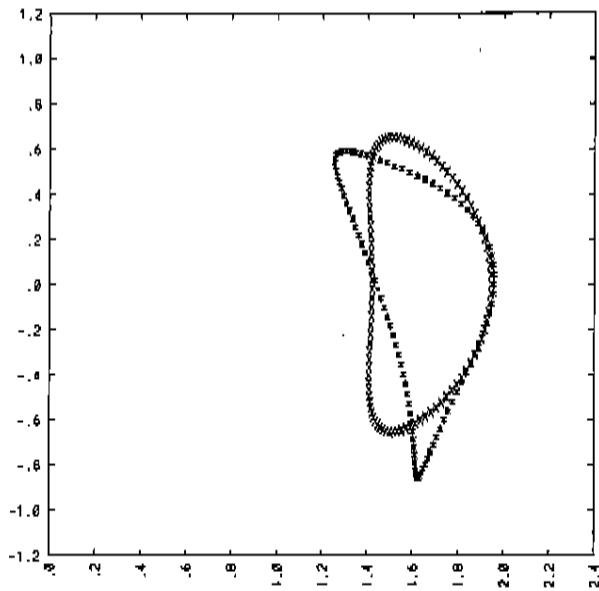
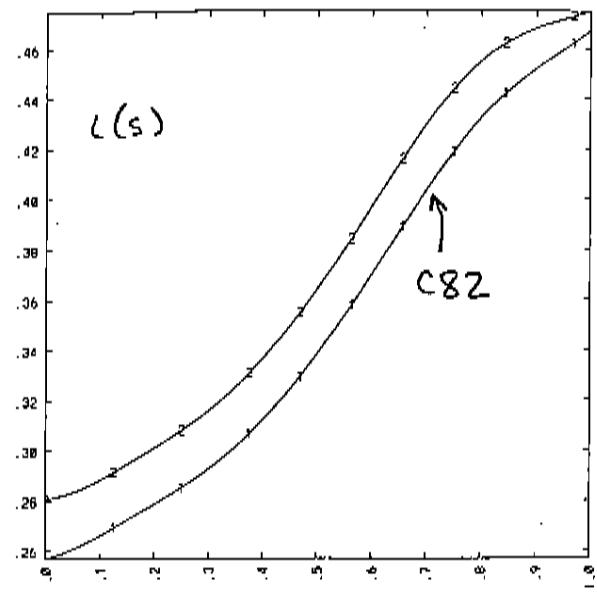
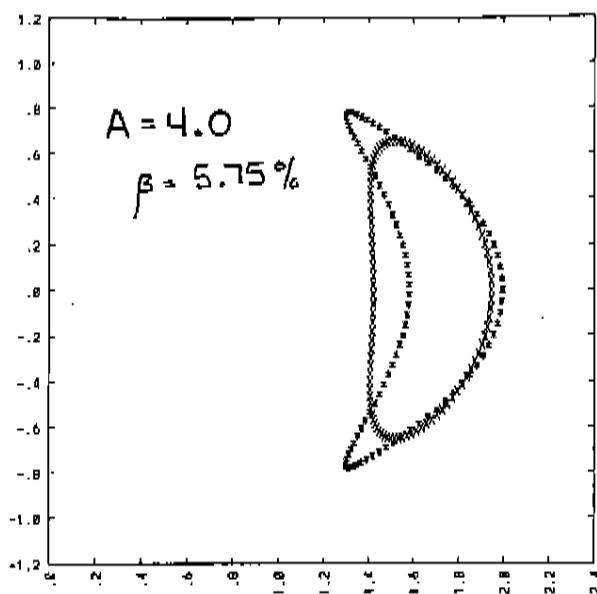
# Results for Aspect Ratio Scan, $\chi = 2.45$

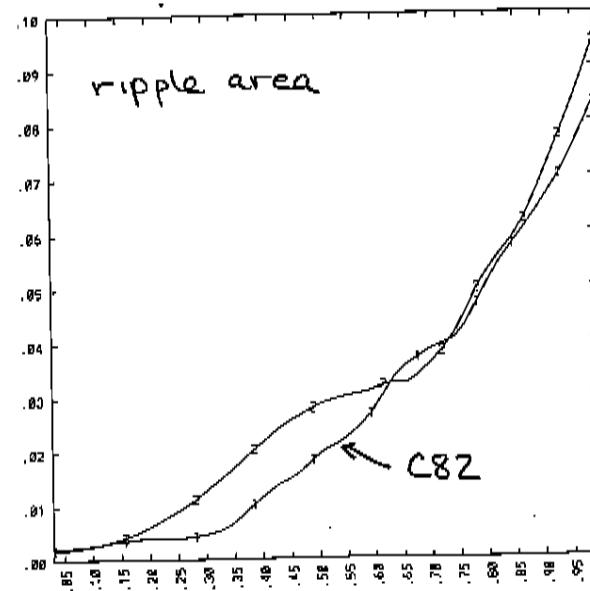
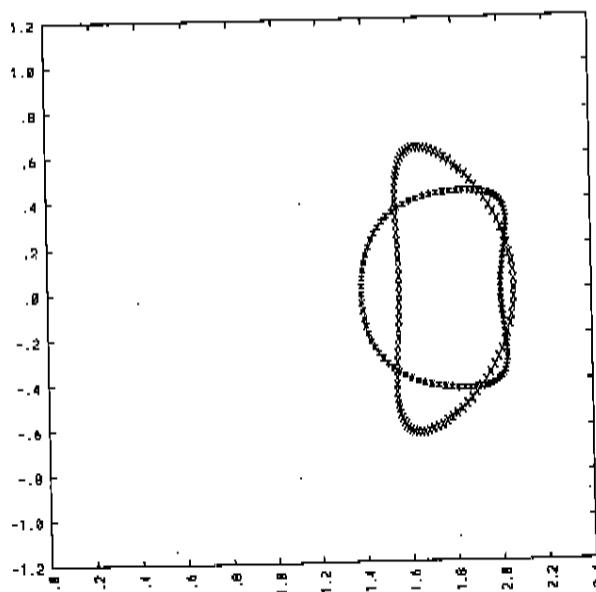
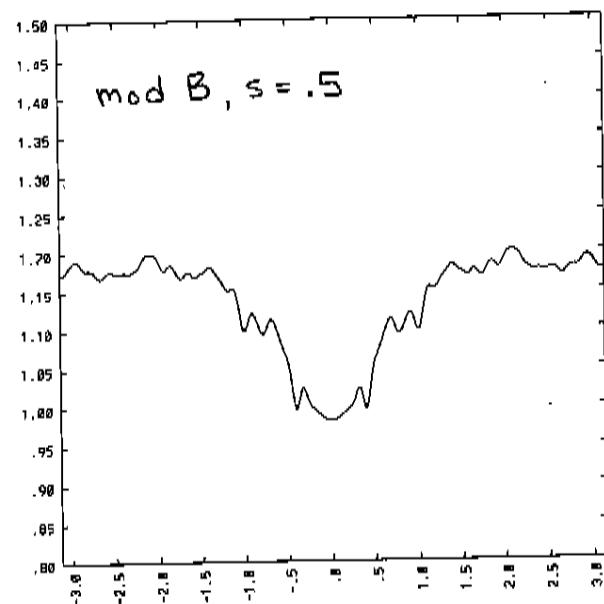
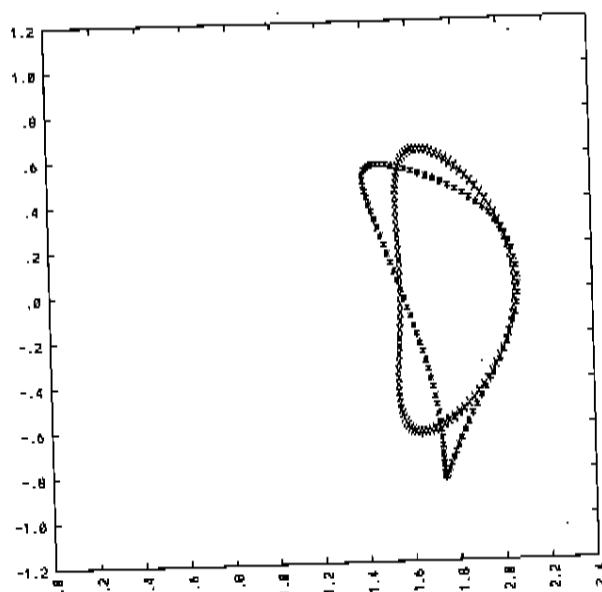
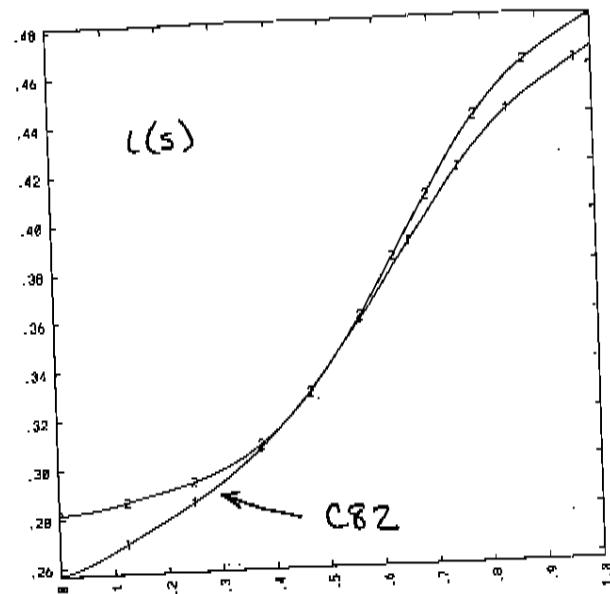
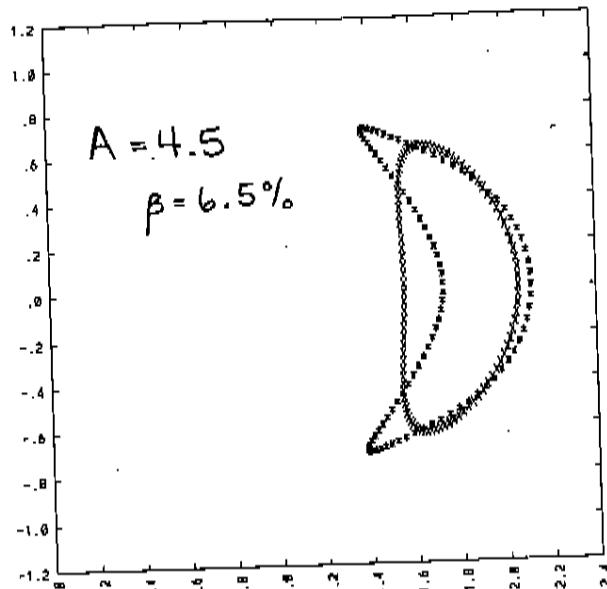
\*  $I$  corresponds to bootstrap current at 4%  $\beta$ , otherwise consistent with  $\beta$

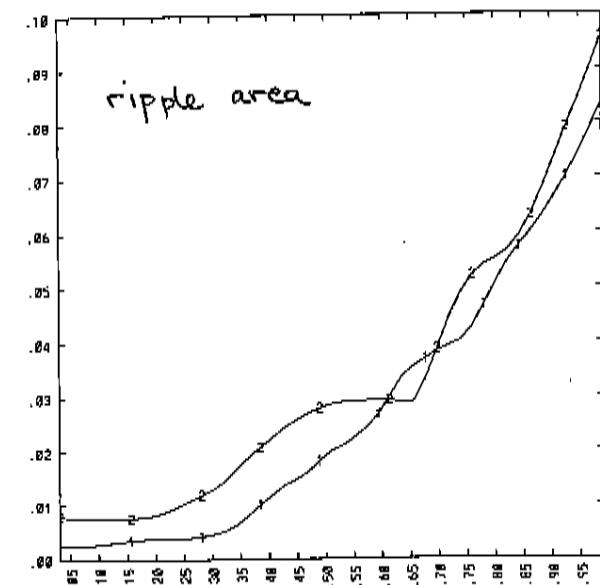
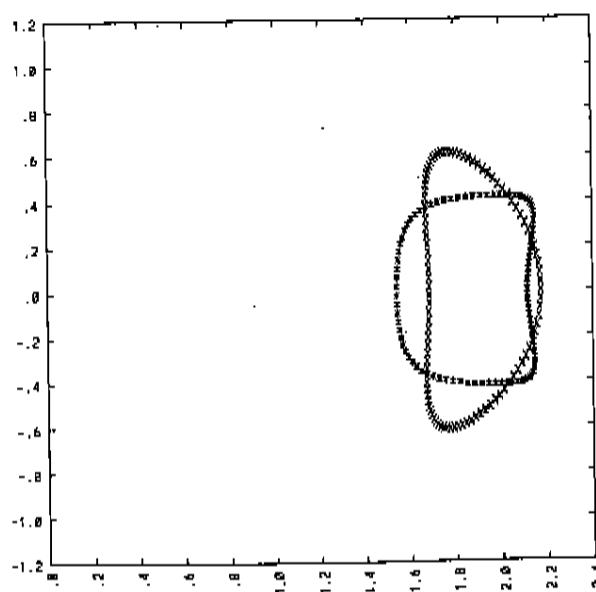
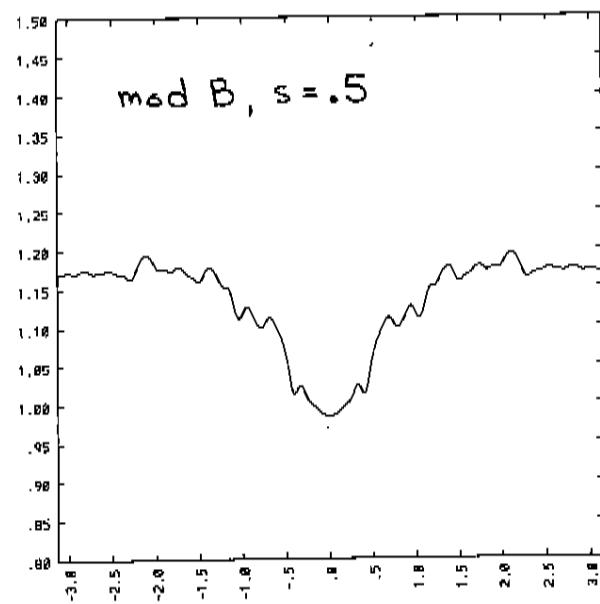
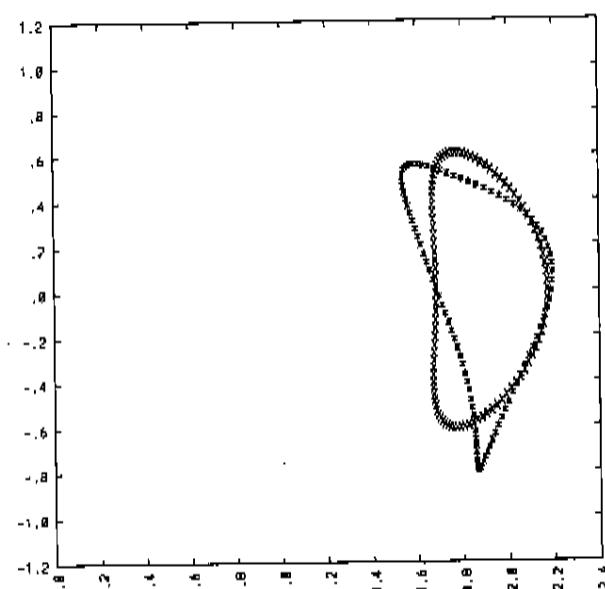
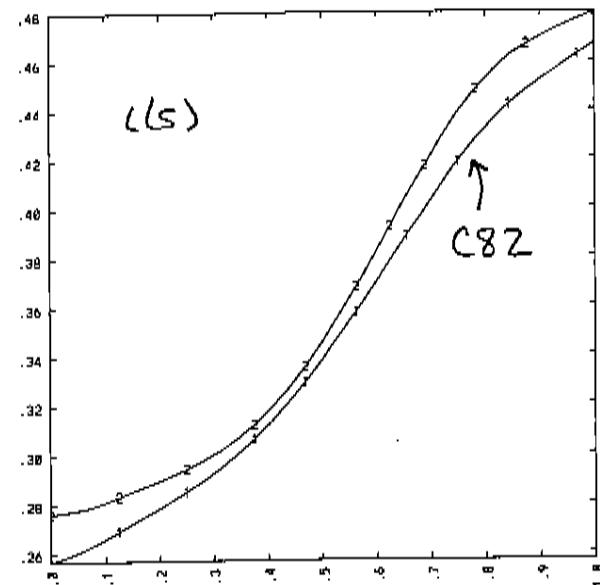
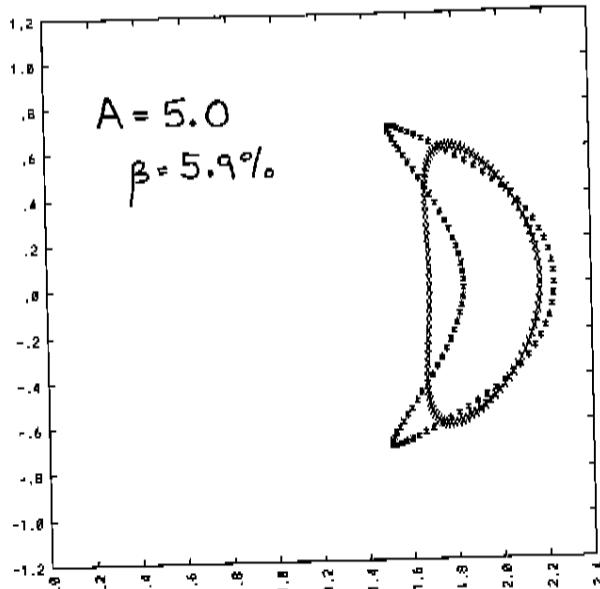
A	$I$ (kA)	$\beta$ (%)	$\lambda_X$	balloon stability	$ B_{min} $	coil complexity	$i(a)$	$i(0)$
3.0	233*	4.5	$-2.4 \times 10^{-4}$	stable	$\leq 1.7\%$	3.06	.489	.249
	( $\tau_E^{GTC} = 23.1$ ms at 4% $\beta$ )							
3.5	225*	5.25	$.8 \times 10^{-5}$	stable	$\leq 0.95\%$	2.73	.498	.250
	( $\tau_E^{GTC} = 19.3$ ms at 4% $\beta$ )							
4.0	207*	5.75	$-.32 \times 10^{-4}$	stable	$\leq 0.66\%$	2.77	.479	.280
	( $\tau_E^{GTC} = 25.5$ ms at 4% $\beta$ )							
4.5	188*	6.50	$-.72 \times 10^{-4}$	1 surface	$\leq 0.58\%$	2.92	.481	.282
	( $\tau_E^{GTC} = 23.7$ ms at 4% $\beta$ )							
5.0	175*	5.90	$-.10 \times 10^{-3}$	stable	$\leq 0.60\%$	2.89	.480	.276
	( $\tau_E^{GTC} = 23.0$ ms at 4% $\beta$ )							
4.0	232	4.75	$-.28 \times 10^{-4}$	1 surface	$\leq 0.48\%$	2.84	.483	.301
4.0	244	5.00	$-.35 \times 10^{-4}$	1 surface	$\leq 0.60\%$	3.02	.484	.308
4.0	255	5.40	$-.5 \times 10^{-4}$	1 surface	$\leq 0.76\%$	3.27	.479	.309
4.0	266	5.75	$-.63 \times 10^{-4}$	1 surface	$\leq 0.90\%$	3.62	.478	.316

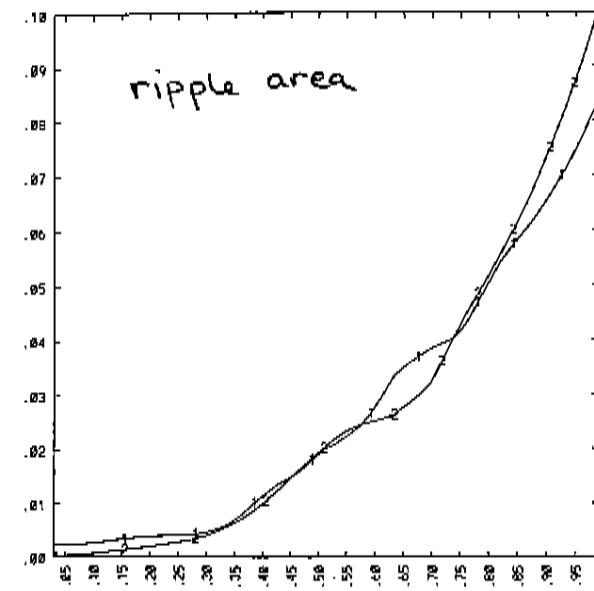
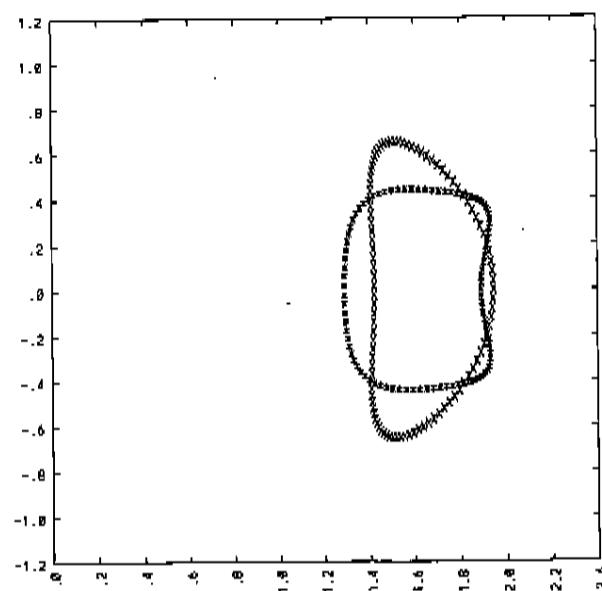
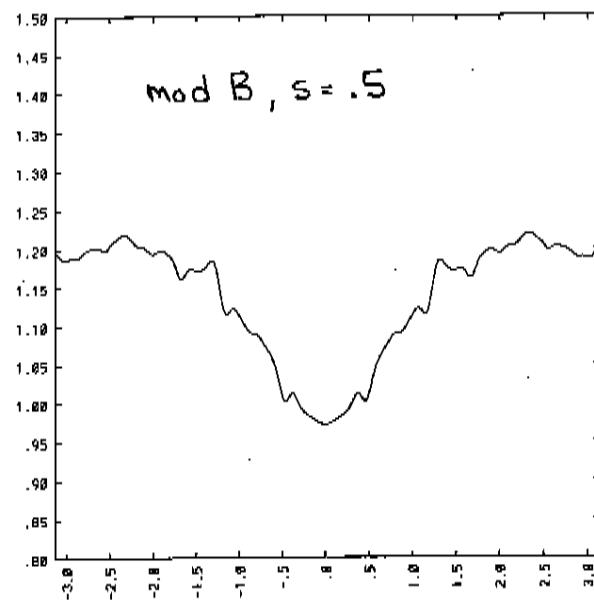
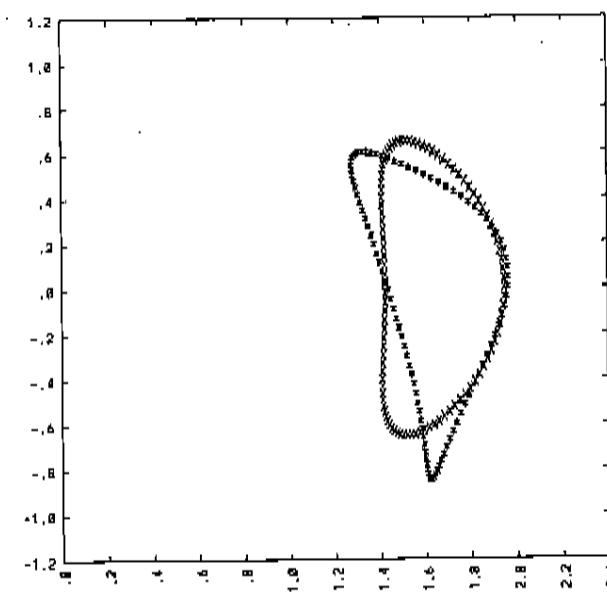
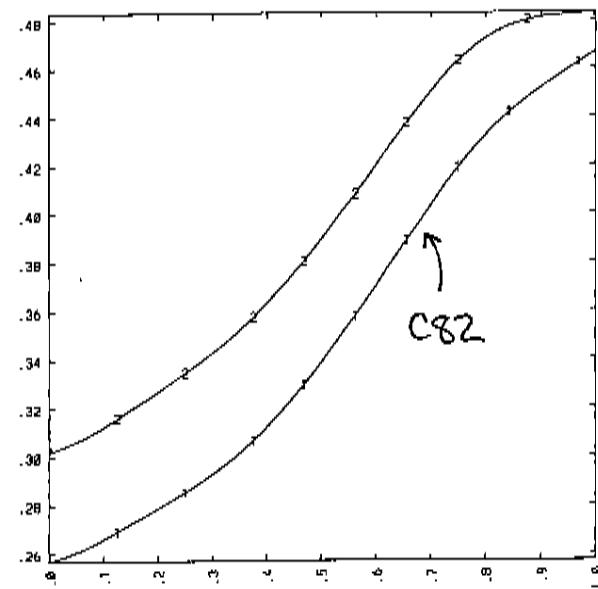
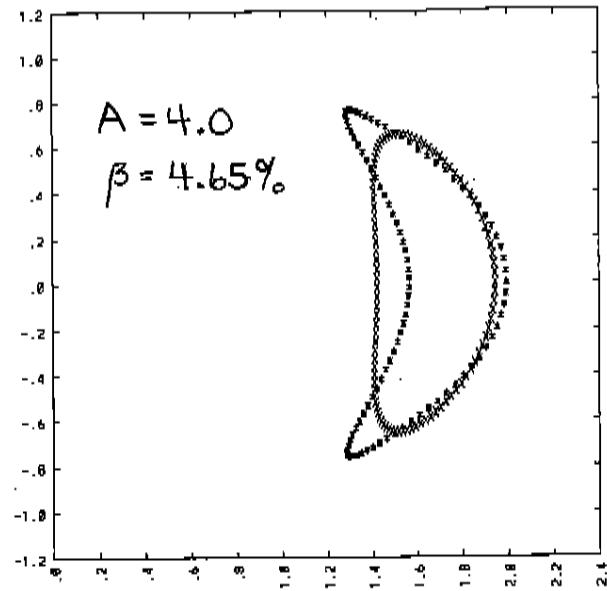




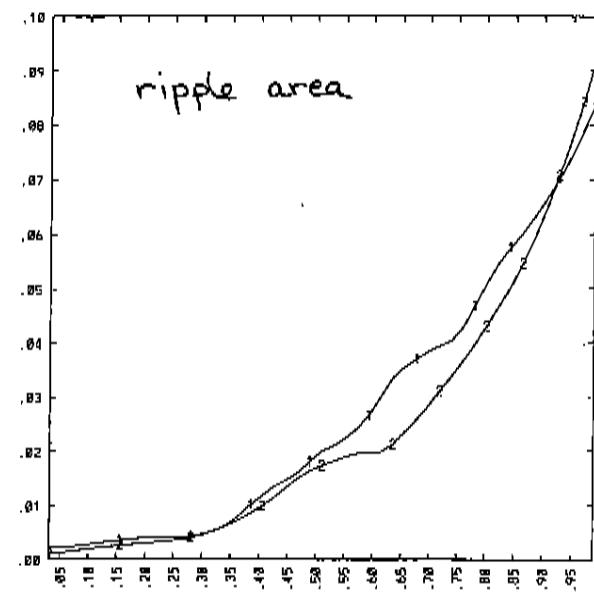
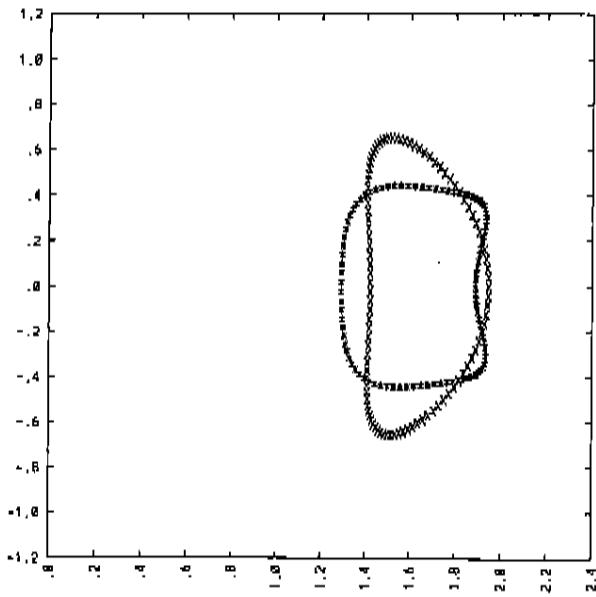
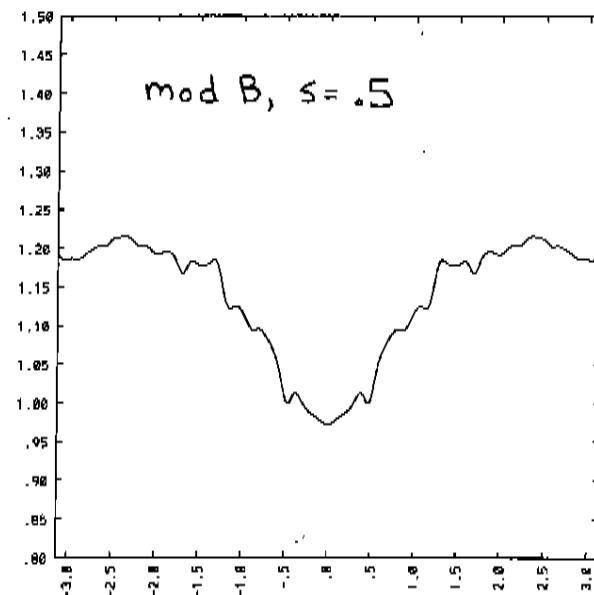
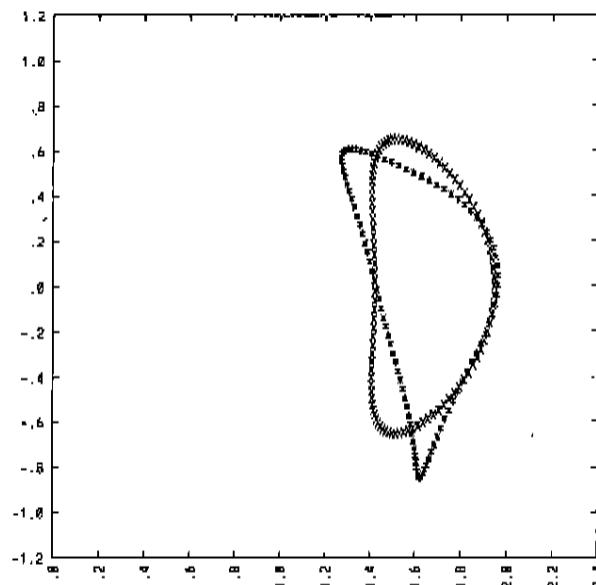
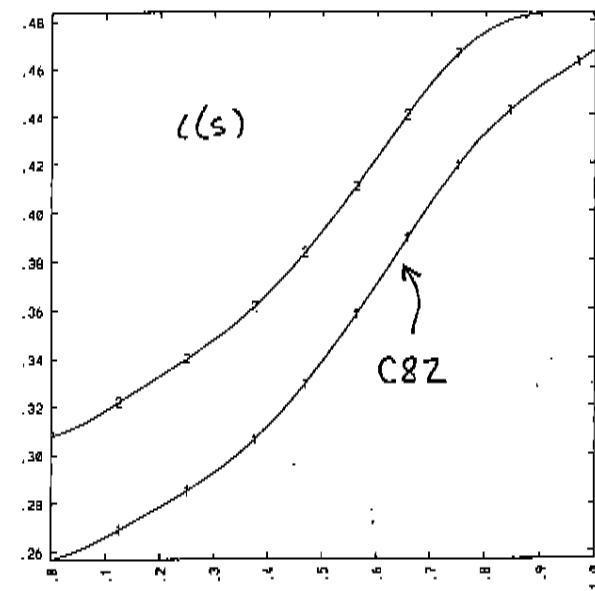
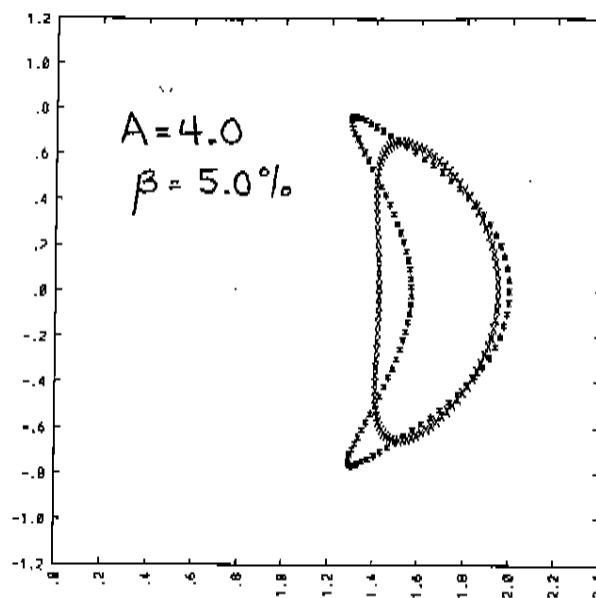


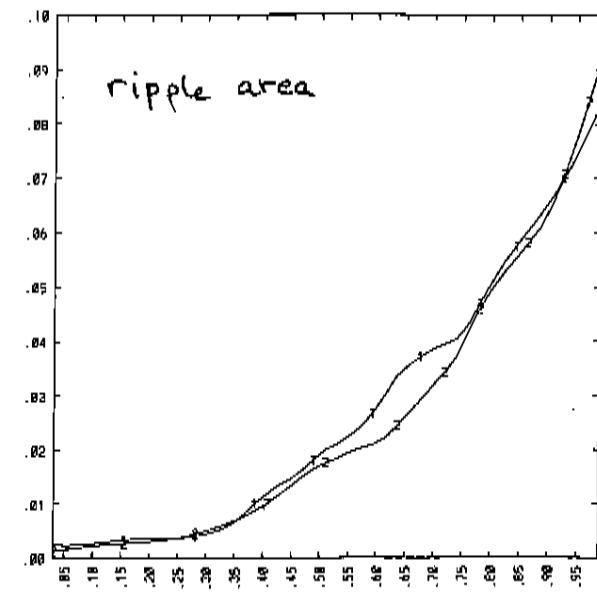
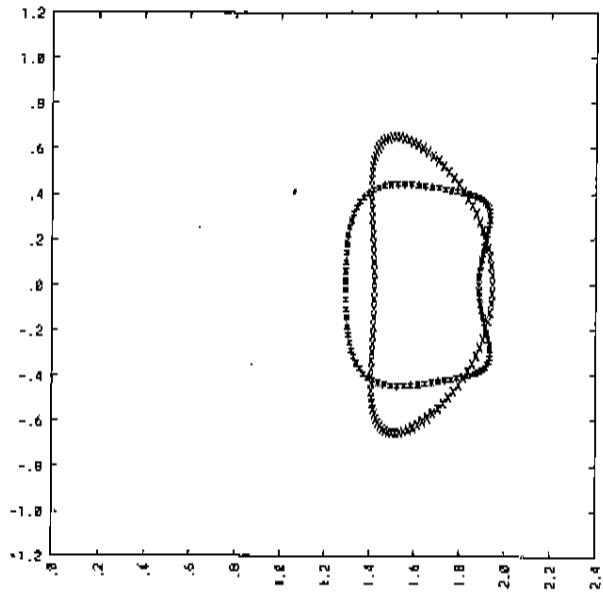
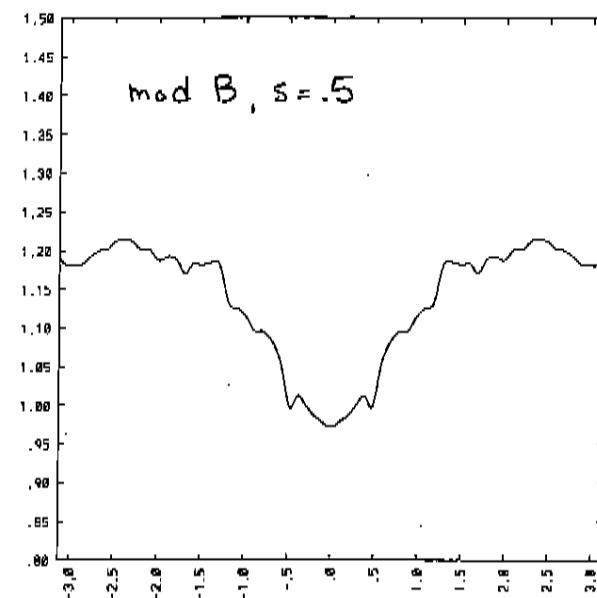
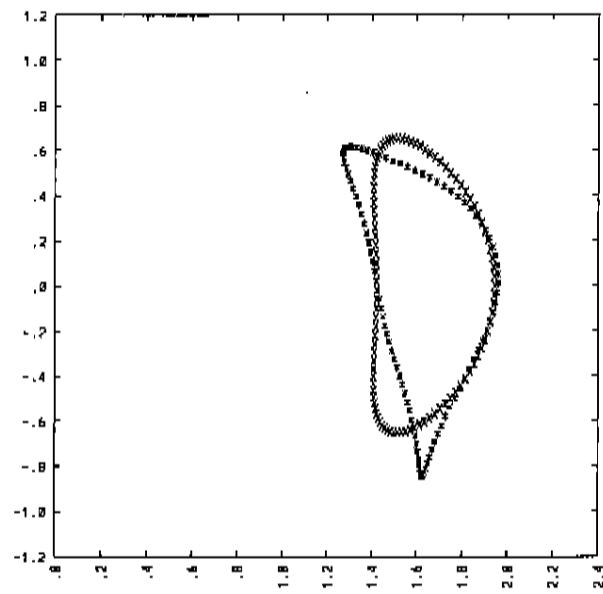
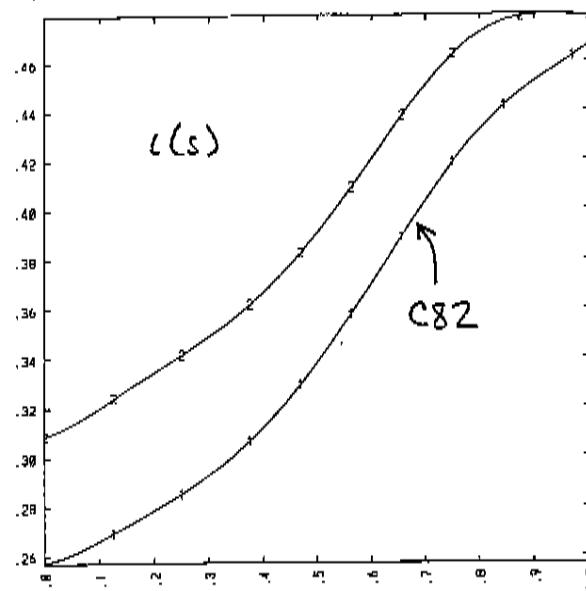
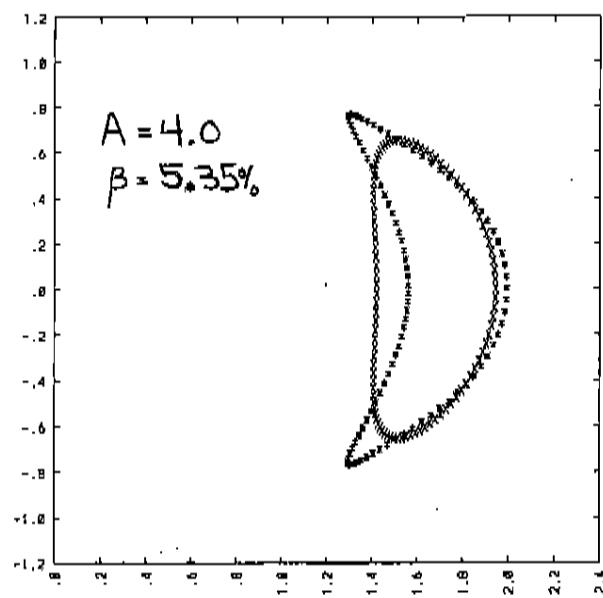




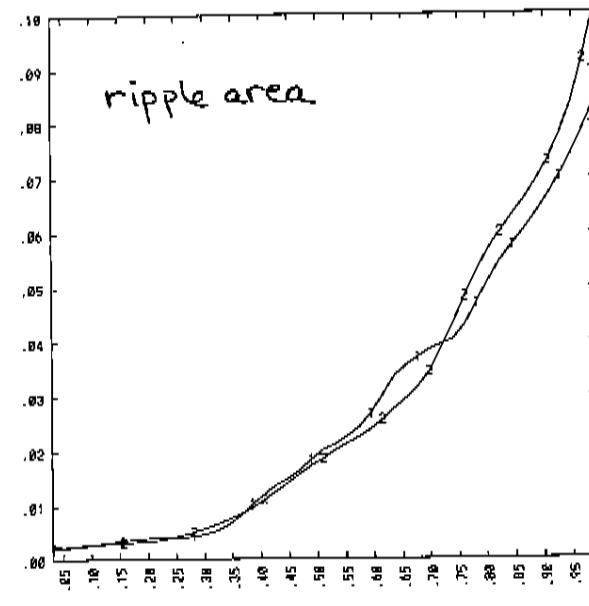
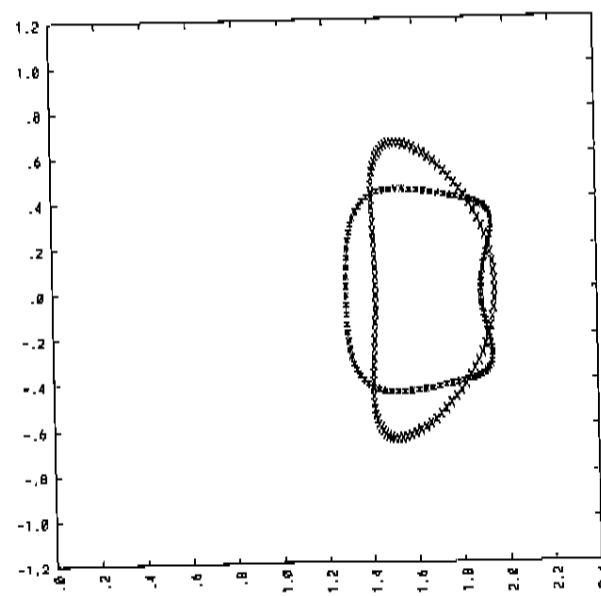
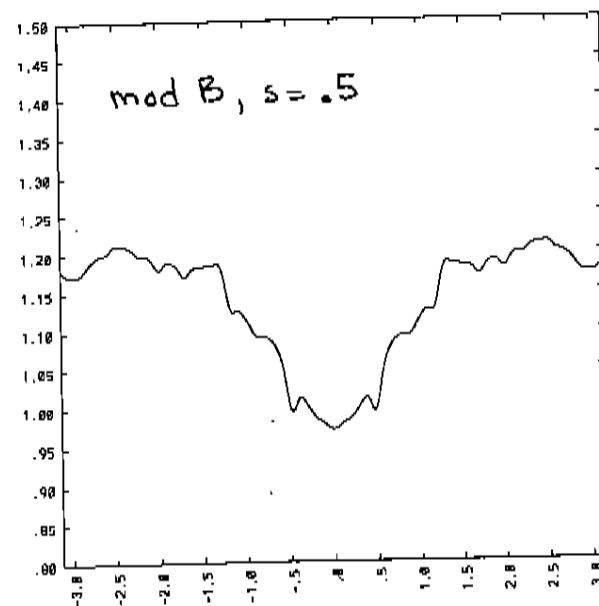
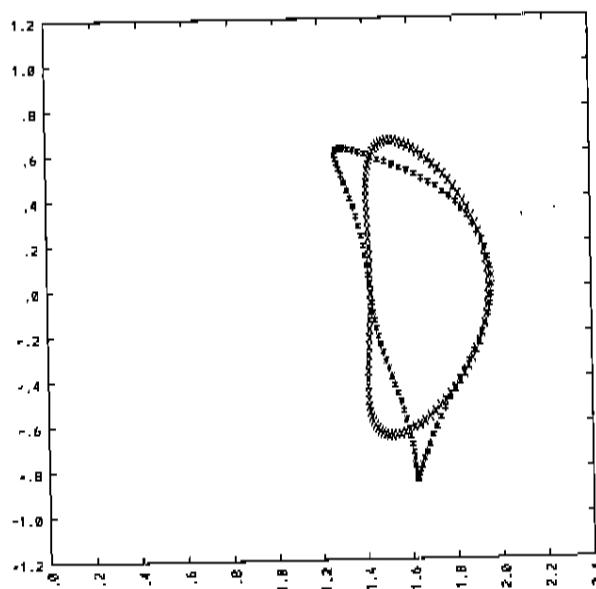
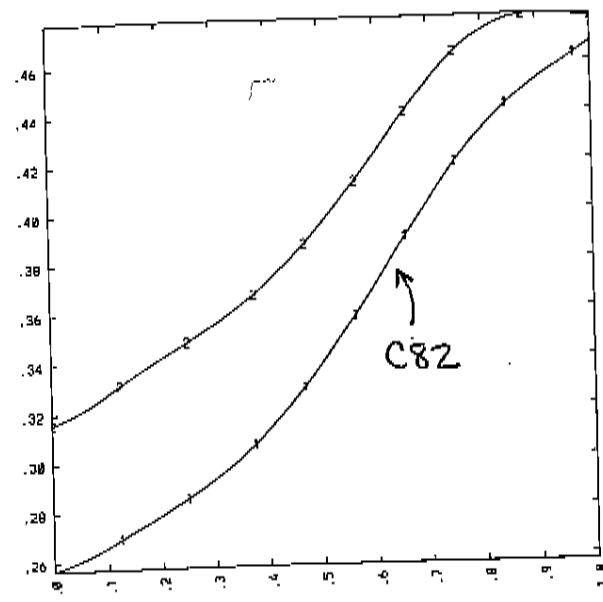
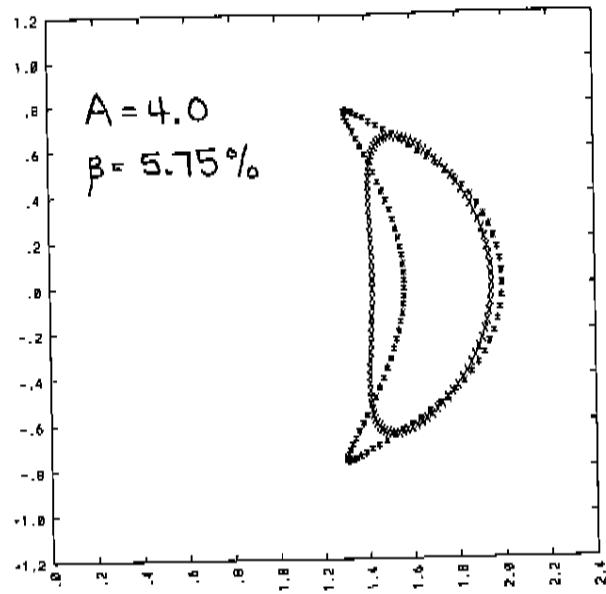


(9)





(II)



## Observations & Plans

- higher elongation in combination with higher aspect ratio appears to access higher  $\beta$ , and improved confinement at fixed current
  - with actual bootstrap consistent current this result may still hold, but plasma shaping/coils may limit  $\beta$  increase
- bootstrap consistent current constraint causes the current to rise as  $\beta$  is increased, eventually resulting in stronger plasma shaping (external transform) to stabilize the kink mode
  - stability, coil complexity, and possibly QA are very sensitive to current in plasma — we might examine ways to reduce it / control it
- lower aspect ratio appears to require higher  $|B_{mn}|$ , however, whether this is bad for confinement is not clear
  - higher aspect ratio appears to require lower  $|B_{mn}|$
  - is there a toroidicity/helical trade-off for confinement over the range of aspect ratios we're examining ??

- complete  $X - A$  matrix ;  $X = 1.9, 2.45, 3.0$   
 $A = 3.0, 3.5, 4.0, 4.5, 5.0$

→ return to C82 elongation to fill in

→ increase elongation

→ maintain bootstrap consistency

- <sup>complete</sup> bootstrap consistent current scan at  $A=4.5, X=2.45$

- take closer look at lower aspect ratio

→ do higher  $|B_{mn}|$  infer worse  $T_E$ , as we increase  $\beta$

→ does lower  $A$  help to keep bootstrap current low

→ take a look at very low  $A$ ,  $A=2-2.5$

- examine different  $i(s)$  regime with  $X \neq A$ ; allow  $i(a) > .5$  with  $i(0) < 0.5$

- develop comparison of transport measures

$|B_{mn}|$

neo

DKES