PRELIMINARY RESULTS OF SIMULATION OF A
SAWTOOTH CRASH IN CDXU WITH \( q(0) = 0.98 \)

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CDXU EQUILIBRIUM - $q(0) = 0.97$

- $q_0 = 0.97$
- $P_e = 0.95 \, P$
- $k_{\parallel} = 1 \, \text{m}^2/\text{sec}$
- $k_{\text{perp}} = 10^8 \, \text{m}^2/\text{sec}$
- Spitzer resistivity
- $S = 1.9 \times 10^4$
- $Pr = 10^2$
- $50 \times 50$ poloidal grid
- Bi-quartic elements
- 11 toroidal modes
  - $n = 0-10$
- 176 cpus on seaborg
LINEAR STABILITY - LOW $q(0)$

- Two low-$n$ modes are linearly unstable (in nonlinear run)
- $n = 1$
  - Sawtooth mode
  - Dominant $m = 1$, but small $m = 2$ component
- $n = 2$
  - $m = 2$ mode dominant
  - $m = 3$ and $m = 4$ components
- $n = 3, 4, ..., 10$
  - No sign of linear instability
LINEAR EIGENFUNCTION - $n = 1$

$n = 1 \ J_o$

$m = 1$ and $m = 2$ ($m = 3?$)
LINEAR EIGENFUNCTION - $n = 2$

$n = 2 \ J_0$

$m = 2$ and $m = 3$ ($m = 4?$)
NONLINEAR CALCULATION

- $n = 1, 2$ linearly unstable
- $n = 0, 3-10$ nonlinearly driven
- $n = 1$ changes from 1/1 to 2/1, 3/1, etc and continues to grow -> tearing modes?
EVOLUTION OF $q(0)$
$n = 1$ MODE CHANGES CHARACTER

Before sawtooth saturation

- $1/1, 2/1, 3/1, \ldots$
- Kink mode with harmonics

After sawtooth saturation

- $2/1, 3/1, 4/1, \ldots$
- Tearing modes?

$t = 2.5 \times 10^{-4}$ sec.

$t = 4.20 \times 10^{-4}$ sec.
FIELD LINES

$t = 0 \text{ sec.}$
$t = 2.5 \times 10^{-4}$ sec.
FIELD LINES

\[ t = 2.86 \times 10^{-4} \text{ sec.} \]
FIELD LINES

\[ t = 2.97 \times 10^{-4} \text{ sec.} \]
FIELD LINES

$$t = 3.06 \times 10^{-4} \text{ sec.}$$
$t = 3.17 \times 10^{-4} \text{ sec.}$
FIELD LINES

\[ t = 3.29 \times 10^{-4} \text{ sec.} \]
FIELD LINES

\[ t = 3.54 \times 10^{-4} \text{ sec.} \]
FIELD LINES

$ t = 3.81 \times 10^{-4} \text{ sec.} $
$t = 4.20 \times 10^{-4} \text{ sec.}$
DETAIL OF FIELD LINE STRUCTURE NEAR $q=2$ SURFACE

Onset of stochasticity?

$t = 4.20 \times 10^{-4}$ sec.

Secondary islands near $q = 2$ separatrix
• Sawtooth \((n = 1)\) mode grows and saturates
  – \(n = 2\) also linearly unstable
  – \(q(0)\) is raised above 1
  – \(q(0)_{\text{max}} \sim 1.065\)
• \(n = 1\) mode changes character after sawtooth saturation
  – Changes from 1/1 to 2/1, 3/1, ....
  – Transition from kink mode to tearing mode?
• Field does not become completely stochastic for as long as case was run
  – Many secondary islands around 2/1 separatrix
  – Need to run further to determine stochasticity
  – Interesting to look at \(q(0) > 1\) case