Ideal MHD stability of NT

Antoine Merle

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Motivation

Main objective

Assess the potential differences in global $n = 1$ ideal MHD stability of positive and negative triangularity plasmas.
TCV equilibria will be used as a first example.

- 69271: diverted NT
- 69515: diverted PT [1]

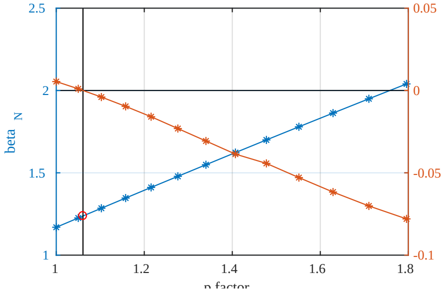
[1] Smoothed equilibria archive in TSVV2 wiki does not contain EQDSK files, only gyropsi HDF5 files and EXPTNZ kinetic profiles

Reviving the β_N limit workflow for TCV

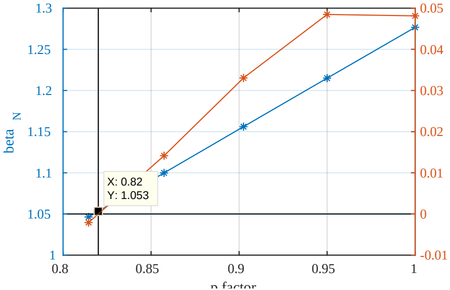
(Initial work by S. Medvedev and O. Sauter)

- Workflow description
  - Assess the $n = 1$ ideal MHD stability of the base equilibrium
  - Gradually scale up (or down) the pressure profile (usually $dp/d\psi$) with respect to the current density $I^* = \langle \mathbf{J} \cdot \nabla\varphi \rangle / \langle \|\nabla\varphi\| \rangle$ until the stability has changed.
  - Because we consider $n = 1$ we need to avoid the internal kink solution (responsible for sawteeth), and thus we usually impose a fixed value of $q_0 > 1$.
  - The workflow uses a combination of CHEASE (for the base equilibrium), CAXE (to produce the scaled eq.) and KINX (to assess the ideal MHD stability).
- Main work:
  - Translate shell scripts to MATLAB functions
  - Use latest advanced features of KINX (automatic search for most unstable eigenmode).

First results in the no-wall limit ($a_w/a \sim 5$)



$\beta_N \sim 1.2$ for $q_0 = 1.20$

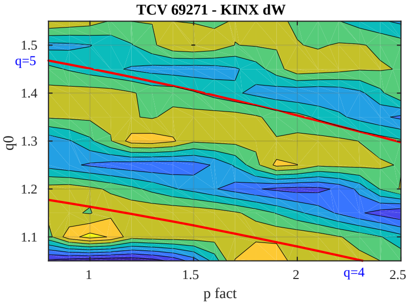


$\beta_N \sim 1.05$ for $q_0 = 1.10$

(Right axis is δW, negative values correspond to unstable eq.)

- Results seemed quite sensitive to the chosen value of q_0 and hints of non-monotonicity of the growth rate with respect to β_N were found (and persisted with increased radial and poloidal resolution)

Influence of q_{95}, q_{edge}



(Blue is unstable, yellow is stable)

- Stability index levels align more or less with q_{95} levels.
- Different unstable regions correspond to different dominant poloidal harmonic: $m = 4$ if $q_{edge} \sim 4$, $m = 5$ if $q_{edge} \sim 5$, etc.

~~Conclusions~~ First impressions

- Allowing q_{95}, q_{edge} to change with β_N does not seem like a viable path. Also the results should be resilient to small changes in q_0 (~ 0.1).
  - $\Longrightarrow$ CHEASE allows to scale the pressure profile while keeping the whole q profile fixed. My next goal is to use this feature to assess the changes in stability.
- It was suggested that wall stabilization (i.e. reducing the value of a_w/a) can reduce the influence of q_0. This will be investigated as well.

Backup Slides

~~Conclusions~~ First impressions

- Early studies for TCV (Turnbull et al.) or more recent ones for NT reactors (Medvedev et al.) use parametrized profiles and optimization procedure to find the optimal β_N value. This yields a global limit for one particular shape, but might not be adequate to tell if one can still increase the plasma pressure in a particular discharge without hitting an ideal MHD limit.