1. Introduction
>
A Q=10 burning ST (BurST) is analysed with parameters from Table 1

To produce net energy on the grid it is necessary to

- Minimise auxiliary heating
- Maximise fusion power
- Equilibrium generated with the SCENE code
- Specified temperature and density profiles
- H\textsuperscript{\textsc{\textcircled{\textdegree}}} factor used to estimate the required quality of confinement

Predictive transport modeling required to assess feasibility

TGLF\textsuperscript{1,2} is a quasi-linear gyrofluid turbulent transport solver used to estimate anomalous transport

JINTRAC has been used to examine the energy confinement with TGLF

TGLF standard settings are for tokamaks, recalibration needed for STs

Model a shaped ST device, R/a=1.9 - electrostatic and no pressure gradient

Fitted to DIII-D like equilibria, looking at BurST has larger trapped particle fraction, so it must be re-examined

θ

Reduce aspect ratio

3. GS2 vs TGLF - Simplified geometry
>
Comparison made with a simplified version of a BurST equilibrium

- Kinetic gradients
- Aspect ratio (R/a=3.0)
- Miller parameters
- Electrostatic (B=0)
- Magnetic geometry

No pressure gradient (p'=0)

Qualitative agreement between two codes for linear growth rates at mid-radius

TGLF generally overestimates growth

Quantify difference with following formula

\[
\sigma^2 = \frac{1}{N} \sum_{n=1}^{N} \left( \frac{\sigma_{\text{TGLF}}^n - \sigma_{\text{GS2}}^n}{\sigma_{\text{TGLF}}^n + \sigma_{\text{GS2}}^n} \right)^2
\]

\( \sigma_{\text{GS2}} = 58\% \) for default settings

Increasing number of basis functions from 4 to 8 reduces \( \sigma = 45\% \)

Eigenfunctions qualitatively match at \( k_{\rho,\text{mid}} \), where growth rates peak in ion/electron scales

4. Reduce aspect ratio
>
Model a shaped ST device, R/a=1.9 - electrostatic and no pressure gradient

TGLF fitting parameter \( \theta_{\text{trap}} \) sets boundary between Landau resonant and Landau averaging trapped particles - guesses \( k_1 \) as \( \theta_{\text{trap}} \propto 1/k_1 \)

\( \theta_{\text{trap}} \) will impact trapped particle drive

- Fitted to DIII-D like equilibria
- BurST has larger trapped particle fraction so it must be re-examined

Look at \( \rho_\text{high} \) in 3 regions, best results at \( \theta_{\text{trap}} = 0.4 \)

Table 2. Showing difference in growth rates for different TGLF settings for an electrostatic BurST equilibrium. Colours correspond to \( \rho = 0\% \), 10\% \( < \rho < 50\% \), \( \rho = 50\% \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major/Minor Radius (m)</td>
<td>2.5/1.5</td>
</tr>
<tr>
<td>Elongation</td>
<td>2.9</td>
</tr>
<tr>
<td>( \beta_\text{n} )</td>
<td>5.1</td>
</tr>
<tr>
<td>Safety factor on axis</td>
<td>2.5</td>
</tr>
<tr>
<td>Fusion Power (MW)</td>
<td>1100</td>
</tr>
<tr>
<td>Auxiliary Power (MW)</td>
<td>110</td>
</tr>
<tr>
<td>B at ( R_a ) (T)</td>
<td>2.4</td>
</tr>
<tr>
<td>Plasma Current (MA)</td>
<td>21.2</td>
</tr>
<tr>
<td>H\textsuperscript{\textsc{\textcircled{\textdegree}}} Factor</td>
<td>1.2</td>
</tr>
<tr>
<td>( T_e (x10^{20} \text{m}^{-3}) )</td>
<td>1.5</td>
</tr>
<tr>
<td>Core ( \theta_{\text{out}} ) (keV)</td>
<td>28</td>
</tr>
</tbody>
</table>

Figure 2: Evolved ion (left) and electron (right) temperature profiles with TGLF. The sensitivity to TGLF inputs in the BurST regime motivates this study to improve the model.

Figure 4: Comparison of eigenfunctions in ballooning space for the \( k_{\rho_\text{high}}=0.6 \) (left) and for \( k_{\rho_\text{mid}}=0.3 \) (right) for TGLF and GS2.

5. Summary
>
Shaped R/a=3.0 aspect ratio plasma -> qualitative agreement between TGLF and GS2 in the electrostatic limit

- Growth rates/frequencies match reasonably well but the growth rates were generally overestimated in TGLF

- Increasing number of basis functions from 4 to 8 improves the agreement for the simplified geometry cases

- More basis functions results in a longer runtime, balance must be found

- For the R/a=1.9 device reducing \( \theta_{\text{trap}} \) from 0.7 -> 0.4 resulted in a better agreement

- Need to optimise for a range of flux surfaces to find appropriate settings

- Look at iteratively setting \( \theta_{\text{trap}} \) using the \( k_1 \) calculated for the eigenmode

- High \( k_1 \) modes have the highest discrepancy -> need to minimise this

- Future work will be to further optimise TGLF for equilibria with high \( \beta \) and \( \rho \) as this will have significant impacts on the eigenmodes

- Using the optimised parameters JINTRAC will be used to assessed the performance of BurST

References


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