Gyrokinetic simulations of transport in pellet fuelled discharges at JET
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Introduction

- Pellet injection is the likely fuelling method of reactor grade plasmas.
  - Will temporarily perturb density and temperature profiles and change key dimensionless parameters such as \( a/L_m \), \( a/L_T \), \( \nu_m \), and plasma \( \beta \) affecting transport properties.
- L-mode pellet injection experiments were performed during 2014 hydrogen campaign.
  - Diagnostic set-up optimized to measure post pellet evolution of density profiles.
  - Accurate equilibrium reconstruction and Gaussian process regression\(^1\) fits of the kinetic profiles were performed as basis for gyrokinetic analysis.
- Following microstability analysis of MAST pellet fuelled discharge where stabilization of all modes was found in negative \( a/L_m \) region\(^2\).

Discharge parameters

- The discharge 87847 is analysed at several radial positions around the pellet ablation density peak.
- \( B = 1.7 \text{T}, I_p = 1.75 \text{MA}, P_{\text{CRH}} = 3.45 \text{MW}, T_i = T_e \) and \( n_i = n_e \) is assumed.
  - Focus on time point with the largest density peak, \( t = 0.002 \text{s} \) after the pellet injection.
- Results compared to intra pellet time point with relaxed profiles at \( t = 0.032 \text{s} \) after pellet.

<table>
<thead>
<tr>
<th>( \rho_t \mid t ) [after pellet]</th>
<th>( n ) [10^19/m^3]</th>
<th>( T ) [eV]</th>
<th>( \nu_m )</th>
<th>( \rho_m )</th>
<th>( \rho_e )</th>
<th>( \beta ) [%]</th>
<th>( q )</th>
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<td>0.0042</td>
<td>3.81</td>
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<td>2.64</td>
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<td>6.71</td>
<td>4.33</td>
<td>11.36</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Table 1: Discharge parameters

GENE simulations setup

- Both linear and nonlinear simulations of ITG/TE mode turbulence performed using the gyrokinetic code GENE\(^2\) in a flux tube domain.
  - Including finite \( \beta \) effects and collisions in realistic geometry.
  - Fast particles and rotation are not expected to play important role in this low-\( \beta \), ICRH heated discharge and are not included.
- For nonlinear GENE simulations, simulation domain in the perpendicular plane of \( L_n \sim 125 \sim 250 \rho_p \) and \( L_m \sim 110 \sim 200 \rho_p \) with a typical resolution of \( \rho_m, n_m, n_i, \nu_m, \nu_i, T_i \mid \rho_m = [14, 48, 32, 64, 16] \).
  - Collisionless simulations included in order to connect results to more reactor relevant conditions.

Linear results

- Eigenvalue spectra at \( \rho_i \) subdominate modes dented.
  - With collisions the normalised growth rates are slightly reduced in the pellet case in the negative \( a/L_m \) region.
  - Negative \( a/L_p \) stabilising but partially undone by increase in \( a/L_T \).
  - In the collisionless case the stabilisation at the pellet time point is more pronounced.
  - Subdominant TE-mode with reduced growth rates appears at pellet time point without collisions, collisions stabilise it.

Nonlinear results

- Particle flux inwards in negative \( a/L_m \) region, changes sign on the outside of the pellet ablation peak.
  - Similar magnitude on each side of the pellet ablation peak.
  - In negative \( a/L_m \) region diffusion coefficients are lower after the pellet than at intra-pellet time.
- The outward heat fluxes are greatly reduced in negative \( a/L_m \) radial range compared to intra pellet case.
- Collisionless simulations at \( \rho_i = 0.09 \) and \( \rho_i = 0.94 \) exhibit larger particle fluxes than collisional case in unchanged direction.
- Poloidal flux spectra remain similar at both time points.

Conclusions

- ITG mode growth rates slightly reduced in negative \( a/L_m \) radial range.
- Outward heat fluxes and diffusion coefficients reduced on inside of the peak compared to intra pellet time point.
- Particle fluxes on each side of the peak were of similar magnitudes and in opposed directions, suggesting a symmetric evolution of post-pellet density profiles.

Acknowledgements and references

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