Light impurities in JET plasmas: transport mechanisms and effects on thermal transport


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INTRODUCTION

A series of experiments was carried out in JET ILW L-mode plasmas in order to study the transport of light impurities and their effects on core thermal transport. These discharges feature the presence of He, Be, C, N, whose profiles are all measured by active Charge Exchange, although with different degrees of accuracy. To study the effects on ion heat transport, ICRH power was deposited on- and off-axis mainly to ions in (He)D minority scheme, in order to have a scan of the ion heat flux versus R/L\textsubscript{Te} and also modulated for ion heat wave propagation. The density profiles of the light impurities in the plasma and the comparison with quasi-linear and non linear gyrokinetic simulations are shown. The impact on ions and electrons heat transport of the presence of nitrogen in the plasma is studied both analysing the experimental data and with gyrokinetic simulations.

LIGHT IMPURITY TRANSPORT

C-wall, L-mode plasmas. B high rotation, L-mode plasmas. B heat wave propagation. The density profiles of the light impurities in the plasma and the comparison with quasi-linear and non linear gyrokinetic simulations are shown. The impact on ions and electrons heat transport of the presence of nitrogen in the plasma is studied both analysing the experimental data and with gyrokinetic simulations.

Figure 3: Radial density profiles of He, Be, C and N. The density profiles of the same species are similar at all the discharges in which they are measured. The C profile is measured only for the discharge 86740 (N=0%), as the nitrogen has a big impact on the CX analysis of the C lines. The Plume effect is not considered for the He profile. The dashed purple lines are the profiles for a discharge with high rotation.

Table 1: Comparison between the experimental peaking of the impurities density profiles, the quasi-linear gyrokinetic simulations and with nonlinear gyrokinetic simulations (GWMK [2] and GENE [3]).

<table>
<thead>
<tr>
<th>Species</th>
<th>R/L\textsubscript{Te,exp}</th>
<th>QL</th>
<th>NL</th>
</tr>
</thead>
<tbody>
<tr>
<td>He</td>
<td>0.33</td>
<td>2.5 +/- 0.5</td>
<td>1.25</td>
</tr>
<tr>
<td>Be</td>
<td>0.5</td>
<td>2.8 +/- 0.5</td>
<td>0.7</td>
</tr>
<tr>
<td>C</td>
<td>0.50</td>
<td>2.5 +/- 0.5</td>
<td>/</td>
</tr>
<tr>
<td>N</td>
<td>0.33</td>
<td>1.8 +/- 0.3</td>
<td>1.3</td>
</tr>
</tbody>
</table>

The simulations underestimate the density peaking of the He and overestimate the peaking of C and N. The simulations indicate that important mechanisms [4] for the turbulent particle transport are the thermo-diffusion and the pure pinch, while the eco-diffusion is less important (1/20 of the others).

Figure 2: Neoclassical/turbulent contributions to the particle transport for N (red) and C (black). Left oriented triangles represent the diffusive part of the transport while right oriented triangles represent the convective part calculated with the NEO code [1] and results to be negligible , compared to the turbulent transport, outside \(\rho\textsubscript{\perp} > 0.2\).

Figure 4: R/L\textsubscript{Te} vs R/L\textsubscript{Te} (left) and electron-scale (right). The stabilization effects of ITG are due to main ion collisionality and higher T\textsubscript{e} and s/q [6,9]. Stabilization of TEM is due to higher collisionality and higher s [5,7]. Stabilization of ETG is due to higher T\textsubscript{e}/T\textsubscript{i}.

CONCLUSIONS

- Radial density profiles of four light impurities in a JET L-mode ILW discharge are shown.
- Known mechanisms for impurity transport in plasma are studied.
- The simulations underestimate the density peaking of the He and overestimate the peaking of C and N.
- The simulations indicate that the most important mechanisms for the turbulent transport are the thermo-diffusion and the pure pinch.
- The effect of the N on thermal transport is studied. The general effect is a stabilization of both the electron and the ion turbulent transport. The stabilization is due to different mechanisms, directly or indirectly caused by the presence of N.