Gyrokinetic study of transport suppression in JET plasmas with MeV-ions

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As next-generation fusion devices, such as ITER, will be heated by fusion-born alpha particles, assessing the impact of such particles on microturbulent transport is crucial. The development of experimental scenarios mimicking burning plasma conditions in present fusion devices reveals thereby essential to efficiently predict unexpected transport regimes in the presence of alphas. Recently, a JET scenario [1] offered the possibility to study the impact of ions in the MeV range on the turbulent transport. The efficient application of the three-ion heating scheme [2] generated a significant population of MeV-ions, mimicking the alphas' energy. Surprisingly, despite the strong Alfvén activity and the dominant electron heating in the plasma core, the ion confinement was improved [1]. Thus, extensive gyrokinetic modelling studies, solving self-consistently both large MeV- and bulk-ion scales with the GENE code [3], have been performed for the first time in a realistic validation framework. It is shown that a complex multi-scale mechanism leading to the ion-scale turbulent transport suppression is underlying [4]. Fully destabilized TAEs, excited by the highly energetic ions, play a determinant role, nonlinearly coupling to the zonal flow dynamics, as demonstrated by multi-mode analyses. The so-triggered zonal flows suppress the ion-scale turbulent transport only in the presence of unstable TAEs, as further validated against experimentally measured plasma density fluctuations. Since alpha particles are expected to destabilize TAEs in ITER [5], this study indicates that similar conditions may be realized also in ITER burning plasmas.

References

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