Turbulent transport at the pedestal top of small-ELM plasmas at JET: key mechanisms and their impact

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A new high performance H-mode plasma regime with small-ELMs has been recently discovered at JET [1]. This new regime is obtained by operating with low or no gas injection, and it is referred to as Baseline small-ELMs (BSE) since the achieved plasma conditions are relevant for the ITER baseline scenario, such as $q_{95} = 3.2$, $\beta_{\mathrm{p}} < 1$, $\beta_{\mathrm{N}} = 1.8 - 2$, $\mathrm{H}_{98} = 1 - 1.4$, and low pedestal collisionality ($\nu^*_{e,\mathrm{ped}} = 0.1 - 0.4$).

In this study, to develop a physical picture of the edge dynamics, the turbulent transport acting at pedestal top of these new regimes is investigated, by comparing it to a standard H-mode with type-I ELM. The analysis is conducted by means of local gyrokinetic simulations using the GENE code [2]. The analysis of the micro-instability spectra [3] already reveals the main differences between the two regimes: at the ion-scales, the type-I ELM regime is dominated by hybrid ITG-KBM while hybrid TEM-ITG modes are found in the BSE regimes; at the electron scales, ETG modes dominate both regimes.

For the first time, the investigation of the non-linear physical mechanisms governing the pedestal turbulence has been carried out for a selected BSE regime. At the ion-scale, we found that at the reference plasma β a strong non-linear electromagnetic stabilization, leading to an enhanced zonal flows activity, is crucial to get turbulent fluxes compatible with observations. In addition, our findings reveal that electromagnetic stabilization dominates over that provided by the strong external $E \times B$ shearing, which shows an ambivalent role as strongly stabilizes turbulence in the linear phase but enhances heat flux in the non-linear phase. Finally, electron-scale simulations demonstrate that the electron heat flux is stiff with respect to R/L_{T_e}, and it is able to provide the missing transport to retrieve the experimentally inferred $Q_e/Q_i > 1$ heat fluxes ratio.

The results obtained in this work give precious insights on turbulent transport mechanisms dominating at the pedestal top of BSE plasma regimes, allowing for experimental interpretation and plasma regimes optimization in view of future applications.

References

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