Turbulent transport and their mechanisms in Wendelstein 7-X plasmas

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Traditionally, radial transport in stellarators is dominated by a high neoclassical (NC) contribution. In tokamaks, as this contribution is inherently minimal, thanks to the symmetry of the device, the radial losses are essentially attributed to turbulence [1]. The optimized Wendelstein 7-X (W7-X) stellarator is designed to reduce the NC transport down to tokamak levels. Results from the first experimental campaign in W7-X suggest that NC transport is not sufficient to explain the radial losses in several scenarios (specially at the edge $r_{eff} > 0.6$), opening the door to the turbulent transport contribution as a plausible candidate to explain these discrepancies.

The present work performs a turbulent transport analysis using linear and nonlinear gyrokinetic simulations for stellarator geometry [2] with the GENE [3] code in Wendelstein 7-X experimental plasmas and direct measurements of the machine. The milestones of the study are: i) identify when the turbulent transport becomes relevant in different configurations with real plasmas, ii) characterize the turbulence according to the instabilities present in the experiment and, in addition, iii) compare the numerical results with direct measurements of the W7-X diagnostics.

Different drift-wave instabilities are studied (mainly driven by the ion temperature gradient and the trapped-electron mode [4]) using experimental profiles of density and temperature from the OP1.2a W7-X campaign (provided by Thomson scattering and XICS inversion). These profiles are obtained from high-density discharges, with a significant temperature gradient in the core and density gradient localized in the edge. Two magnetic configurations, standard and high mirror, are used to analyse the optimization properties and their effects on the device's transport such as turbulence stabilization [4]. In order to compare with diagnostics' measurements at fixed positions (reflectometers, CECE, PCI, etc), special attention to the evolution of the instabilities and how they propagate is considered and studied. Power-balance analysis is also used to assess the relative role of NC and turbulent processes in the overall heat transport.

References

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