Width of scrape-off-layers in circular & diverted plasmas: a turbulent model confronted to experimental evidences

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Control of power loads on plasma facing components in current and future tokamak reactors largely dependents on perpendicular transport properties setting the scrape of layer width. This contribution aims at showing that interchange turbulence is a likely candidate, first in inner limited geometry, but also in diverted one. After confronting experimental evidences and simulation results, implications for future reactors are discussed.

For limited circular geometries, a 2D interchange transport model is validated against a broad set of fluctuation properties and mean density and heat load profiles collected in Tore Supra [1]. In particular (1) the ExB drift velocity of plasma filaments (blobs) are reproduced by an isolated blob model, and (2) values of the SOL width are matched by a regression scaling - on global control parameters - constructed from numerical simulations. Both agreements are within 30% error. The model scaling for λ_q depends mainly on the poloidal magnetic field strength, including weaker but finite sensitivity with machine size and total magnetic field strength. Predictions for ITER start-up phases reproduce recent extrapolations based on multi-machine regressions [2], let aside the possible existence of a narrow feature.

Extension of the model to diverted geometry has to suffer the evidence that λ_q is generally much smaller in this configuration than for circular inner limited plasmas, which cannot be explained by the 2D model in its state. On the other hand: (1) Experimental scaling laws constructed on JET and AUG L-mode lower single null data [3] return a parametric sensitivity of λ_q in good agreement with the model. (2) Recent TCV data [4] confirm this agreement. It points toward the existence of a positive sensitivity of λ_q with machine major radius. (3) Recent 3D flux driven turbulent simulations of the edge of both circular and diverted plasmas, made with TOKAM3X, show that interchange turbulence dominates transport in both cases and λ_q is much narrower (1:6) in diverted than inner limited configurations, ratio similar to experiments. Ongoing works focus on the role of magnetic shear & expansion effects on transport mitigation.

Implications are twofold. First, estimates of λ_q for ITER, either based on multi-machines extrapolations or drift-based heuristic approaches, could be too small by a factor of at least 2. Second, interchange turbulence is also likely to take place in the divertor volume. Simulations with TOKAM3X on equilibria with increasing length of the outer divertor leg - in TCV-like geometry - show that λ_q increases with the leg length whereas divertor spreading S does not [5]. These results are in good agreement with recent experimental evidences from TCV [4,5]. Besides questioning the physical interpretation of λ_q & S, it opens new perspectives in the optimization of turbulent transport in alternative divertor configurations.

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