Scrape-off layer turbulence: theory, modeling and implications

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Edge and scrape-off-layer (SOL) physics is a subject of growing importance in fusion research. Tokamak boundary plasma stability, turbulence and transport plays an important role in determining the interaction of the plasma with the material boundaries and impacts recycling, rf antenna coupling, and possibly the density limit. In the edge and near-separatrix SOL, gradient driven instabilities give rise to strong ($\delta n \sim n$) turbulence which can saturate by a combination of sheared flows and profile modification. In this region, meso-scale structures usually call blob-filaments [1,2] can arise from the turbulence and convect into the far SOL. Separatrix-spanning convection, blob-filament birth and dynamics, Reynolds stress, and sheared flows are of fundamental importance. These processes are impacted by plasma sheaths, plasma resistivity, and the resulting current loops which can be sensitive to the SOL magnetic geometry, such as X-points as well as to plasma parameters. The interactions show different behaviors with plasma density and temperature ranging from sheath-connected blob-filaments in the low density limit, to disconnection for a high density, high collisionality SOL. The status and challenges of modeling these regimes, and comparing their predictions with experiments will be discussed.

A programmatically important aspect of SOL turbulence studies is an understanding of the SOL heat flux width. Understanding the responsible mechanisms and resulting scaling of the SOL heat flux width is important for predicting viable operating regimes in future tokamaks, and for seeking possible mitigation schemes. Simulation and theory results using reduced edge/SOL turbulence models [3-6] have produced SOL widths and scalings in reasonable accord with experiments in many cases. Simulation results will be discussed together with ongoing work that is attempting to qualitatively and conceptually understand various regimes of edge/SOL turbulence and the role of turbulent transport in establishing the SOL heat flux width.

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