Turbulent transport in tokamak divertor legs

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Cross-field transport below the X-point governs the behaviour of tokamak divertors in several important respects: modifying the distribution of heat and particles within and between divertor legs, thereby changing the fluxes to divertor surfaces, and modifying the onset and evolution of divertor detachment. The physics basis for this transport is incomplete, thereby significantly increasing uncertainties in our predictions for future devices. In this work the foundations for such a physics basis, routed in turbulent transport, will be presented via complimentary experiments on European devices, alongside detailed comparisons to high fidelity models of tokamak boundary turbulence.

Filaments produced by turbulence localised to the divertor volume have been observed on several devices including MAST, TCV and JET in L-mode and H-mode, suggesting that divertor turbulence is ubiquitous to present-day tokamaks. In MAST the inner and outer leg filaments are shown to be decoupled. Velocimetric measurements of the inner leg show radial filament velocities into the PFR in the range 300 – 600ms^{-1} which coincide well with the measurement of ion saturation current at the target plate, demonstrating a close relationship between filamentary transport and profiles. High fidelity simulations of turbulence in MAST are being produced with the STORM module of BOUT++[1]. Simulation results compare very favourably with the MAST experimental database indicating that they capture turbulent processes in the divertor well. Analysis of these simulations shows that turbulence is a prevalent cross-field particle transport process in both divertor legs, but varies in nature between the two. The magnetic curvature drives interchange turbulence in the inner divertor leg PFR, but suppresses turbulence in the outer leg which is due to unstably resistive drift-waves.

In TCV the impact of magnetic curvature is investigated by varying the poloidal angle of the outer divertor leg. In low density L-mode scenarios, a horizontal divertor leg (where the stabilizing impact of curvature in the PFR is minimized) results in higher fluctuation levels and increased profile spreading into the PFR as compared to a vertical leg (where curvature effects are maximized). These results experimentally confirm the impact of the magnetic curvature on turbulent transport in the divertor and help to verify the physics basis for turbulent particle transport in divertor legs. Comments on the implications of these results for future devices will be made.

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