Simulating the effects of magnetic geometry on turbulent heat and particle transport in the divertor

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Successful operation of future large-scale tokamaks is dependent on the mitigation of high heat and particle fluxes to divertor target plates. Novel divertor configurations, which require significant modification to the magnetic geometry, such as the Super-X have been proposed as a solution to this problem. However, there is still a significant gap in our understanding of heat and particle transport in advanced divertors and the consequences this may have for the onset and evolution of detachment. Of primary concern in this work is the turbulence dominated anomalous transport perpendicular to the magnetic field lines. Whilst disadvantageous in the core plasma, anomalous radial transport of particles and heat is beneficial for broadening heat and particle flux profiles in the scrape-off layer (SOL) and into the private-flux region (PFR). Here, we investigate the physics basis for this transport using high fidelity simulations which self-consistently evolves the instabilities and fluid-neutral interactions driving divertor turbulence.

The plasma model used in this work is encapsulated in a recently developed 6-field drift-reduced 2-fluid BOUT++ module called Hermes-2 [1]. It uses a field-aligned coordinate system, that allows for efficient treatment of a full-geometry simulation domain, as well as a conservative finite volume scheme. Hermes-2 also includes a diffusive fluid model for neutral atoms, in the style of UEDGE [2], to incorporate neutral dynamics.

Presented in this work, are transport simulations of TCV plasmas in horizontal and vertical divertor leg configurations developed within the experiments of the EUROfusion Medium Size Tokamak (MST1) Task Force. Initial 2D (toroidally symmetric, non-turbulent) transport simulations found variation in detachment onset as well as target plate heat flux profiles as a function of the total flux expansion (leg angle). Early 3D simulations of divertor leg turbulence are used to self-consistently generate transport coefficients which will be compared to the 2D ones as well as to experiment. These 3D simulations also offer insight into the effect of leg angle on PFR turbulence and can illuminate processes governing transport across the separatrix in the divertor.