Predictive modelling of turbulence and transport in the edge plasma of magnetic confinement devices

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Understanding the transport processes in the low temperature plasma at the boundary region of magnetic confinement fusion (MCF) devices is of critical importance to the design and operation of next step fusion reactor devices. It influences the divertor heat load, and probably the core confinement as well. While present models of the divertor and Scrape-off Layer (SOL) are successful for interpretative plasma transport, further model development is needed for a truly predictive model. To address that need we have extended the BOUT++ computational platform to study and predict turbulence and transport in the divertor, building on our previous studies of the pedestal and SOL regions upstream from the divertor. We have incorporated (a) improved treatments of the x-point, necessary for advanced divertor geometries; (b) neutral gas & impurity models, to reproduce the transport physics embodied in current 2D SOL/divertor transport codes; and (c) advances in the parallel heat flow model. We have found that collisionless "nonlocal" corrections to the parallel heat transport modify temperature profiles along ***B*** in ways which cannot be represented by flux limiters, particularly during transients (e.g. ELMs), and hence modify plasma-neutral rates. We have explored both fluid and kinetic models for neutrals, and found that turbulence modifies the local neutral gas density – key physics in the detachment process. Conversely, neutral gas is found to affect plasma edge turbulence primarily through momentum exchange, reducing the radial electric field and enhancing cross-field transport, with consequent implications for the SOL width and divertor heat loads. New schemes for treating complex magnetic field geometries in BOUT++, based on the Flux Coordinate Independent (FCI) method, show promise for extending our studies to 3D stellarator geometries. Progress in integrating all the elements being developed into a fully 3D predictive simulation will be discussed.