Global gyrokinetic simulation including SOL-like boundary layer

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The gyrokinetic framework is understood to be the state of the art first principle model to address turbulent transport in magnetically confined plasmas. Up to now, global and flux driven simulations of the core plasma transport have been investigated with the GYSELA code. A key issue, leading to growing concern, is the impact of the actual boundary conditions on the overall transport properties. This has led us to implement SOL-like boundary conditions. The edge-SOL physics that can now be investigated have proven to be quite complex, leading in particular to long transients. This work reports some of the important results that have been obtained, first the development of large scale flows, the generation of an interface transport barrier at the separatrix, and, depending on conditions, destabilisation of this barrier by a tertiary instability.

The simulation set-up is a circular plasma cross-section, comparable to that of Tore Supra experiments, a heating source in the core, with constant heating power and a penalised region corresponding to the limiter. This immersed boundary is defined by a mask that locates the limiter in the simulation volume and where the actual gyrokinetic equations are modified. First the limiter region acts as a heat sink; second, in the SOL region, the average electric potential profile experiences a restoring force towards \( \Lambda T_e \), the floating potential, while the limiter region is grounded. This twostep penalisation process is used because the electrons are set adiabatic for the chosen GYSELA version. Consequently, under steady state conditions, all the heat coupled to the core plasma is transported and deposited on average in time and space into the SOL. The heat that reaches the penalised region, by cross field transport and mostly by parallel transport is then absorbed by the cold spot. Finally at the chamber wall, slightly modified conditions ensure the absorption of the remaining heat.

Starting from a poloidally homogeneous SOL and from core profiles that are consistent with the heat source to generate steady state turbulence, the simulations are found to exhibit long transients in the edge and SOL regions. One first observes GAM oscillations due to up-down plasma polarisation driven by grad B vertical drifts. At the separatrix, these drifts govern plasma polarisation, and a radial electric field builds-up at the interface. Switching off the vertical drift reveals that the cooling of the SOL, due to parallel transport prior to the onset of turbulent transport, also contributes to the ExB shear layer at the interface. As a consequence of this transient reorganisation of the boundary layer, the ExB shear layer sustains an interface transport barrier. Under conditions with large density and temperature gradients relevant to neoclassical transport conditions, a tertiary instability, consistent with transverse Kelvin-Helmholtz, is triggered. No steady-state condition with neoclassical transport in the edge and SOL regions has been observed.

Fluid simulations with TOKAM-3X and transport modelling with SOLEDGE are being run with similar conditions. They should provide a means to compare the physics and evaluate the role of particle driven transport. Hopefully these could also be used to generate SOL 2D initial conditions for gyrokinetic simulations leading to L-mode conditions.