Building a Turbulence-Transport workflow incorporating uncertainty quantification for predicting core profiles in tokamak plasma.

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Abstract

- A few important aspects when running the Transport, Turbulence and Equilibrium Workflow start from some initial profiles for the temperatures and densities.
- Important to understand energy transport in the core plasma.
- Future challenge will be to bring the pieces of UQ together with the stochastic nature of the internal fluxes from the simulation for the eight flux-tubes, together with a measure of the time-variation, compared to the integral energy source inside each of the flux surfaces for each flux-tube.

Discussion

- Figure: Profile of the electron temperature (left) and ion temperature (right) for a few ASDEX Upgrade discharges.
- Figure: Time traces of the electron and ion temperatures for the positive (solid line) and negative (dashed line) boundary cases, for each of the eight flux-tubes.
- These fluxes are then converted to transport coefficients...together with a measure of the time-variation, compared to the integral energy source inside each of the flux surfaces for each flux-tube.

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References


Figure: The planned Transport, Turbulence and Equilibrium Workflow passing distributions.

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Figure: Turbulence and Equilibrium Workflow.

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Figure: Transport and Equilibrium Workflow using the GEM code in place of the MUSCLE code framework.

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Profile free the Transport, Turbulence and Equilibrium Workflow with a transport model using the new MUSCLE3 framework.

The full workflow uses GEM for the calculation of turbulence fluxes. With eight flux tubes, GEM usually runs on 1024 cores. A typical run consists of approximately 550 cycles of the workflow and takes about 19 hours. Multiple runs are needed before a quasi-steady-state is achieved. The figure below shows a comparison between the full workflow simulations and a few "Standard H-Mode" shots.

Figure: Profile of the electron temperature (left) and ion temperature (right) for a few ASDEX Upgrade "Standard H-Mode" shots, together with simulation results.

- The simulation was set up for an earlier Standard H-Mode shot but not all of the diagnostic signal was available for this similar discharge performed later; some were used as the basis of comparison.
- The uncertainty intervals indicated for GEM are those resulting from the turbulence — not those arising from parameter uncertainties.
- Also plotted are some GEM results with uncertainty information.

Discussion

- one measure of convergence is that the time-average of the calculated fluxes should approach the exact integral — a process that seems to happen relatively quickly.
- One more details on the conceptual aspects of this work can be found in [17] and references therein.

Figure: Time traces of the electron and ion temperatures for the positive (solid line) and negative (dashed line) boundary cases, for each of the eight flux-tubes.

- the electron and ion temperatures shown above have not yet completely saturated.
- the positive triangularity is running with a smaller time-step (use data automatically to limit the changes of temperatures and temperature gradients to a minimum).