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Progress towards the understanding of global effects and negative triangularity improvements with global gyrokinetic simulations

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On the road to fusion energy production, many efforts have been done in order
to address the well-known problem of anomalous transport in tokamak devices.
Understanding and predicting this phenomenon is a key issue towards the development of future fusion reactors. The understanding of turbulent transport has made tremendous
progresses in the last decade thanks to dedicated experimental campaigns, analytical modeling and huge efforts in numerical simulations. Numerical simulations allow us to analyse individually specific features and help us to understand and interpret experimental data. However, we have reached a modelling complexity that makes the simulations extremely challenging: somewhere this complexity has to be cut to obtain results with current computational resources. This does not come for free and each approximation hides some precious information that may be needed to describe experimental observations.
Here, we focus on global effects that can only be observed when the full torus is simulated. We show that in global simulations the Fick law is often an incorrect approximation and that the transport is frequently super-diffusive. This super-diffusivity is typically a result of the overlapping of local transport and avalanche-mediated transport triggered in another plasma region. \\
Among the several features impacting transport non-locality, there are the well-known finite ρ^* effects, the safety factor profile, and the dynamics of electrons. All of these factors will be discussed in the talk.
Boundary conditions as well, a critical issue of gyrokinetic simulations, turn out to be an important source of non-locality: the whole system is very sensitive to the way fluctuations are dissipated at the edge. Clearly it is possible to work in a simplified setup, like the gradient-driven simulations with just core turbulence, where the boundary conditions are less critical but this does not reflect the complexity of a real device.
Equilibrium geometry may also affects non-local properties and transport reduction of certain equilibria may be closely related to non-local effects; consider experiments with negative triangularity, where turbulent fluctuations and transport are reduced compared to the positive triangularity case, even well into the plasma core, where the difference in triangularity is negligible.\\
In the talk, we mostly focus on these global effects comparing simulations performed on two TCV equilibria, corresponding to positive and negative triangularity configurations.

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