Forcing & Self-Organisation in the Core & Near-Edge Plasma

G. Dif-Pradalier[1], Y. Sarazin[1], Ph. Ghendrih[1], C. Norscini[1], J. Abiteboul[2], T. Cartier-Michaud[1], P.H. Diamond[3,4], R. Dumont[1], D. Estève[1], X. Garbet[1], V. Grandgirard[1], Ö.D. Gürcan[5], P. Hennequin[5], P. Morel[5], L. Vermare[5]

[1] *CEA, IRFM, F-13108 St. Paul-lez-Durance cedex, France*
[2] *Max-Planck-Institut für Plasmaphysik, Garching, Germany*
[3] *CASS and CMTFO, University of California at San Diego, CA, USA*
[4] *WCI Center for Fusion Theory, NFRI, Daejeon, Korea*
[5] *Laboratoire de Physique des Plasmas, Ecole Polytechnique, Palaiseau, France*

We wish to discuss how forcing and self-organisation play a prominent role for a wide variety of central plasma observables. Flow and shear organisation, transport near criticality, criticality itself significantly change when allowing for various degrees of refinement in the way forcing and self-organisation are modeled.

One of the most puzzling results in recent years has been the missing transport sometimes reported in fixed gradient gyrokinetic modeling of L–mode tokamak discharges in the the far-core, near-edge region that has come to be known as the "No Man's Land". The question as to whereby this No Man's Land organises remains open and is possibly key to understanding the edge-core interaction and the transition to regimes of improved confinement. This missing transport is associated in modeling to a decrease in the fluctuation amplitude with increasing normalised radius; experimentally the other trend is observed. We address this question asking whether core turbulence can nonlocally spread to the extent that it may solve this transport shortfall conundrum. We use gyrokinetic flux-driven modeling using Gysela where no scale-separation is assumed and the interplay of all scales is self-consitently accounted for. Typical L–mode parameters and experimental profiles are used and a significant fraction of the confinement time has been simulated so far. Though flux equilibrium has not been reached yet, preliminary results tend to show the absence of a shortfall; further analysis is under way as to unambiguously characterise the computed fluctuation levels.

Another important observation has been the finding of a self-organising transport-regulating "staircase" pattern of shear flows in simulations without scale separation assumptions. A novel explanation for the emergence of these structures is discussed. Unexpectedly, a deleterous effect of toroidal rotation, usually understood to be beneficial for the performance of tokamaks as it tends to stabilise MHD instabilities is shown through the erosion of the self-consistently generated micro-transport barriers of the staircase with increased toroidal rotation. In the absence of injected momentum in Gysela, the Reynolds stress efficiently generates local toroidal rotation, with a parallel Mach number typically below 0.2 in the saturated regime. A scan in magnitude and sign of this rotation in the core shows a modification of the flow structure and of the avalanching pattern. Further characterisation of the mechanisms whereby the flow and shear structure and the transport pattern is affected is underway. In particular, the shear layers of the staircase seem to play a role in the NM'sL problem.

At last, the impact of SOL flows is addressed by modifying the usual "no-slip" condition at the radial boundaries. A poloidally asymmetrical profile of parallel velocity is prescribed at the edge, mimicking the expected SOL flow and carrying a net momentum source. The global velocity profile appears as impacted by the change at the boundaries, together with a reduction of mean flow shear through radial force balance. Avalanches are then observed to propagate over larger distances, ultimately leading to a degradation of core confinement. This fact supports the idea that the edge may not be a mere boundary condition for the core plasma. Its relation to the transport shortfall problem is discussed.