Spatial Propagation of Turbulence & Formation of Mesoscopic Structures in Plasma Turbulence

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One of the most puzzling results in recent years has been the missing transport repeatedly 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". This missing transport translates in many channels, *e.g.* for the radial heat transport, the level of turbulence fluctuations or the fluctuations speed as measured by Doppler reflectometry, as order of magnitude discrepancies between experimental and computed estimates. 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. Several cures to find this "missing transport" have been tried, none of which seems currently acceptable. All of these attempts share in common the fixed-gradient (local-like) modeling framework under which the computations are made. We opt here for an alternative approach which emphasises on constraining as weakly as possible the dynamics of the system: the plasma is genuinely modeled as an open system, volumic sources are provided, tailored to meet as closely as possible the actual behaviour observed in a tokamak. Said differently, the plasma profiles are unconstrained a priori, are free to evolve and thus so are the thermodynamic forces which the plasma reacts to. At similar drives of the turbulence [for a given mean pressure gradient] flux-driven models predict different turbulent effective transport coefficients than gradient-driven ones as the additional freedom in the former models allow for a redistribution of free energy in more channels than the turbulent one.

Interestingly, we have consistently found in GYSELA that the interaction between distant regions of the plasma is poorly described when only considering local interactions conspiring together to generate a diffusive transport. Instead, the turbulence propagates through fronts and organised patterns of $\mathbf{E}\times\mathbf{B}$ flows are often formed which we have come to call "staircases". The transport typically organises at *mesoscales* through localisation of shear layers and profile corrugations interspersed between regions of avalanching. We propose to discuss some mechanisms whereby these staircases can emerge, should it be through the onset of heat waves and shocks or through a time delay between the variation of the thermodynamic force and the corresponding flux response, with analogy to jam formation in traffic flow. From a "validation" point of view, we report on an ongoing effort to quantitative comparisons to experimental measurements in physically relevant conditions. We show an encouraging agreement between phase speeds of fluctuations obtained from Doppler backscaterring measurements on Tore Supra and dedicated GYSELA simulations. Magnitudes and trends with radius of turbulent fluxes, fluctuation levels and phase speeds of fluctuations also display a close agreement between GYSELA runs with actual Tore Supra profiles and the experimental measurements, even in the No Man's Land region.