Avalanche, zonal flow and tilt patterns is GYSELA flux driven simulations

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Fusion plasmas are driven far from equilibrium by heating and particle injection. In flux driven simulations, the plasma turbulence then appears to exhibit various mesoscale or macro scale patterns in contrast to the microscale of the instabilities. The understanding and modeling of transport in tokamaks requires properly assessing to what extent does the drive of the system change the turbulence properties. We present the first results of our effort to quantify the difference between flux and gradient driven turbulence in the GYSELA simulations.

We analyze gyrokinetic simulations with ITG turbulence, adiabatic electrons and global geometry. A particular setting in terms of heat source, collisionnality profile, characteristic geometry, is determined according to reference Tore Supra experiments. When analyzing in a 3D plot the flux surface averaged heat flux $Q_{\perp}$ versus radius and time, one can readily see patterns. Two different symmetries are observed, transport structures appear to exhibit ballistic trajectories, with short duration, typically 32 a/c_s, c_s is the sound speed, a the minor radius, and long range radially ~0.4 r / a. For long simulations, these structures appear to be essentially in the radial direction. Conversely, the corrugations driven by the zonal flows have slow motion radially and are appear to be mostly aligned along the time axis. To improve the analysis we introduce a filtering technic with Fourier transforms taking benefit that the turbulent flux vanishes at the boundaries due to diffusive buffer regions that ensure thermal contact at the boundaries while quenching the turbulence. The low wave vectors are filtered out because they mainly contain information of the radial location of the turbulent transport, and the high wave vectors are also removed because their information exhibits little coherence with the large scale structures. When analyzing the minima and maxima of the Reynolds stress data, one readily observes the radial striation of the outward avalanches, as well as several occurrences of inward avalanches. When considering the distribution function in the θ, φ plane at mid-radius - θ is the poloidal angle and φ the toroidal angle- one finds that the avalanches are localized in θ. The structure of the heat flux can then be reconsidered as a tilted structure in the r, θ plane. Localizing the minimums and maximums can then readily yield the outward avalanche pattern provided there is a slightly asymmetry between the radial and poloidal components of the Fourier transform. The structures would then be reminiscent of tilted structures that would be related to Kelvin Helmholtz destabilization of the flow structure organized by the dipolar structure of the avalanche. The Kelvin-Helmholtz instability criteria for an avalanche will be discussed as well as the distribution function within an avalanche compared to background behavior.