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GLOBAL HPC SIMULATIONS IN 5-DIMENSIONS MODEL PLASMA TURBULENCE FROM THE DEEP CORE TO THE SCRAPE-OFF LAYER.

EXTENDING THE GLOBAL AND GYRO-KINETIC CODE GYSELA FOR CORE TURBULENCE TOWARDS THE OPEN FIELD LINE REGION WITH A PENALIZATION TECHNIQUE, TURBULENT FLUCTUATIONS COVER ALL THE PLASMA VOLUME.

The complete understanding of the complex and fully non-linear plasma turbulence phenomena is still one of the missing milestones for the success of fusion experiments. In this perspective, High Performance Computing simulations are needed to support both the theoretical and experimental investigations. The 5D gyro-kinetic and global code GYSELA [1], developed in the CEA-IRFM institute (France), simulates plasma turbulence over the whole toroidal volume of the Tokamak. The code processes ~1Terabyte of data every iteration, being fully parallelized over more than 10thousands processors. Particular emphasis is given to the self-organization of the system: the presence of a source in the very core plasma builds the temperature profile which in turn gives rise to turbulence in a self-consistent way. The heat is transported from the source all way through the plasma volume until it reaches the outer radial boundary, where it is extracted. The way this physics is implemented is crucial in determining the turbulence development and evolution. We have modified the outer radial boundary condition of the code to mimic the experimental limiter configuration: at first, poloidal asymmetry is given to the boundary using a penalization technique [2]. The immersed boundary of limiter shape acts as a perfect heat absorber and extracts all the heat reaching the boundary, consistently with the self-organization. Also, the poloidal asymmetry of the immersed boundary creates a layer in which the magnetic field lines close inside the immersed boundary, the Scrape-Off Layer. At the interface between closed-open field lines regions, the radial electric field changes sign, being mainly governed by the vertical ∇B-drift in the confined region and by the electron dynamics in the open field lines region. The video shows in the colors the time evolution of the electric potential fluctuations all over the 3D toroidal volume, in grey is the penalized immersed boundary. At the very beginning of the simulation, global Geodesic Acoustic Modes (GAMs) are excited by the non-equilibrium initial conditions. Successively, turbulent structures begin to from and spread all over the poloidal section, being elongated along the field lines in the toroidal direction. The poloidal plasma rotation is inverted in the open field lines region with respect to the core, following the sing of the radial electric field.

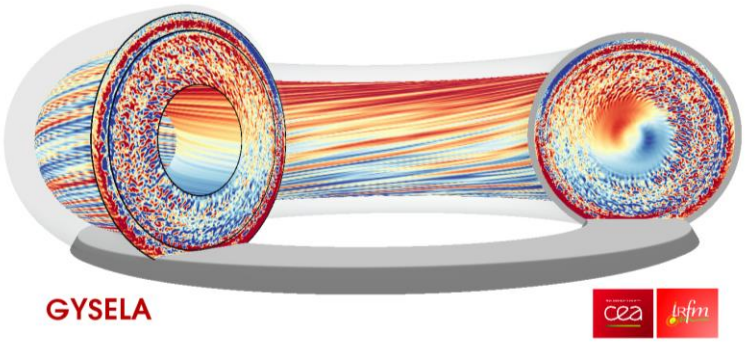

Figure: Snapshot of the turbulent fluctuations of the electric potential in the 3D toroidal volume from a GYSELA simulation with the immersed limiter configuration

REFERENCES

[1] V. Grandgirard et al, *Computer Physics Communication*, 2015.

[2] E. Caschera et al*, Journal of Physics Conference Series,* 2018.

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