Time parallelization of plasma turbulence simulations by application of the Parareal algorithm

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The numerical simulation of turbulent plasmas of interest for magnetic confinement fusion is very computationally intensive due to the large disparity of timescales that play a role in setting the dynamics, which spans many orders of magnitude. It is widely accepted in the fusion community that first principles simulations of ITER-relevant plasmas are currently largely unfeasible, and will remain so for quite sometime unless some important algorithmic advances are made. Currently, the duration of the simulation is limited, and the physics that these codes can address and include must be reduced. Having more CPUs available does alleviate this problem, since most codes do not scale up to the 100,000+ CPUs that current supercomputers offer. In this contribution we will show that a recently proposed scheme to parallelize in time the solution of systems of PDEs can be applied successfully to turbulent plasma simulations, opening an additional parallelization avenue which may offer a solution to the aforementioned limitations, allowing to run longer simulations, and include more complete physics models by better utilizing existing computational resources. It has been shown that fully-developed plasma turbulence can be successfully parallelized in time using the Parareal algorithm [1]. These results plus, a detailed analysis of the error evolution is done in order to obtain a deeper understanding of the mechanisms of convergence. The analysis is performed for slab model of 2D plasma drift wave turbulence in the case of long wavelengths [2] for two types of non-linearities: ExB and polarization. Some suggestions are put forward in order to understand the convergence rates. The same technique is applied to gyrokinetic plasma turbulence simulated with GENE code [3] in order to study the applicability of Parareal to this kind of turbulence simulation, and first results of Gene simulations using the recently released [4] IPS event based platform of Parareal are shown.

References:

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