Recent advances in semi-lagrangian approach for gyrokinetic plasma turbulence simulations

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Predicting the performance of fusion plasmas in terms of amplification factor, namely the ratio of the fusion power over the injected power, is among the key challenges in fusion plasma physics. In this perspective, turbulence and heat transport need being modeled within the most accurate theoretical framework, using first-principle non-linear simulation tools. The gyrokinetic equation for each species, coupled to Maxwell's equations are an appropriate self-consistent description of this problem. A new class of global full-f codes has recently emerged, solving the gyrokinetic equation for the entire distribution function on a large radial domain of the tokamak and using some prescribed external heat source [1]. Such simulations are extremely challenging and require state-of-the-art high performance computing (HPC).

The non-linear global full-f gyrokinetic 5D code GYSELA, which focuses on the electrostatic toroidal branch of the Ion Temperature Gradient driven turbulence with adiabatic electrons, is one of them. One particularity of the code is to solve the self-consistent problem on a fixed grid with a Backward Semi-Lagrangian scheme [2]. Despite the non-locality of this method, the new two-ion-species version of the code has been successfully ported on BlueGene architecture with a relative efficiency of 91% on 458 752 cores (weak scaling). The different numerical locks which have been overcome will be presented.

A second part will be dedicated to the different approaches which have been recently tested to improve the numerical semi-lagrangian scheme in terms of mass and energy conservation. The difficulties linked to the global and full-f character of the code will be discussed.

[1] Garbet X, Idomura Y, Villard L and Watanabe T H, Nucl. Fusion **50** (2010) 043002.

[2] V. Grandgirard et al., Plasma Phys. Control. Fusion, **49** (2007) B173.