Mitigation of initial transients in gyrokinetic turbulence simulations using numerical distribution function with neoclassical relaxation

S. Ku[1], R. Hager[1], C.S. Chang[1], S.-J. Lee[2], A. Scheinberg[3]

[1]Princeton Plasma Physics Laboratory, Princeton, NJ, United States
[2]ITER Organization, France
[3]Jubilee Development, Cambridge, MA, United States

Total-f or full-f gyrokinetic simulations are essential for understanding the edge transport in diverted tokamak plasmas self-consistently. However, standard initialization techniques using a local Maxwellian distribution often generate large-amplitude initial transients, particularly Geodesic Acoustic Modes (GAMs). These transients are particularly severe in the plasma edge due to steep profile gradients, strong radial electric fields, and high safety factors. Such oscillations contaminate radial flux measurements and inflate the computational cost required to reach a saturated turbulent state. To address this, we present a novel initialization scheme for the XGC code that utilizes a numerical distribution function derived from a computationally efficient axisymmetric (neoclassical) simulation. By applying phase-space smoothing with canonical angular momentum conservation to the neoclassical equilibrium prior to full turbulence initialization, we demonstrate significant suppression of artificial GAMs and a reduction in particle noise. Application to the Cyclone Base Case and ASDEX Upgrade I-mode discharges confirms improved physical fidelity and a significant reduction in time-to-solution.

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