Recent Advances in Nonlinear Gyrokinetic Simulation

S. J. Allfrey and R. Hatzky†

simon.allfrey@epfl.ch

*PPB 114,
Centre de Recherches en Physique des Plasmas,
Association EURATOM-Confédération Suisse,
Ecole Polytechnique Fédérale de Lausanne,
1015 Lausanne, Switzerland.*

†*Computer Centre of the Max-Planck-Gesellschaft
and the Institute for Plasma Physics,
D-85748 Garching, Germany.*

Nonlinear gryrokinetic simulation codes seek to elucidate the physics of the steady state (drift-wave) turbulence processes held to be responsible for anomalous transport in magnetically confined plasmas.

The PIC simulation method inevitably suffers from statistical noise. The build up of this noise is a key limitation, determining the duration for which the simulation may be trusted to give meaningful results. Studying the long timescale evolution of the nonlinear state thus requires methods which reduce this noise to a minimum.

The delta-f method approaches noise reduction in implementing a control variates scheme for the approximation of moments of the distribution function. We show such a scheme does not require time integration of the quantity delta-f and that having eliminated such an equation from the scheme, time dependent control variates algorithms become feasible. The method also clarifies the problem of explicit calculation of the error terms in the simulation.

Results are presented of simulation of the drift-wave / zonal-flow system in a cylinder using this scheme together with the importance sampling technique of Hatzky [1].

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[1] R. Hatzky, T. M. Tran, A. Könies, R. Kleiber, and S. J. Allfrey. Energy conservation in a nonlinear gyrokinetic particle-in-cell code for ion-temperature-gradient-driven modes in θ-pinch geometry. *Phys. Plasmas*, 31:898, 2002.