Progress on a Full Radius Electromagnetic Gyrokinetic Turbulence Code*

R.E. Waltz, J. Candy,[1] and F.L. Hinton

General Atomics, P.O. Box 85608, San Diego, California 92186-5608
[1]Oak Ridge Associated Universities, Oak Ridge, Tennessee

Work is in progress to formulate a real gemetry full radius nonlinear electromagnetic gyrokinetic code to simulated high-n turbulence and transport in tokamaks. The nonlinear electromagnetic gyrokinetic equations reduce to those of Frieman and Chen [1] (or Antonsen and Lane [2] linearly) in the ballooning mode or "flux tube" cyclic boundary condition limit. Our code goes beyond the flux tube to a full radius or "wedge tube" which will allow simulations at finite ρ^* including profile shear stabilization effects. It has a mode of reduced operation in the flux tube limit and is expected to recover the ($\rho^* \rightarrow 0$) gyroBohm scaled results from a similar gyrokinetic code being developed by Dorland and Kotschenreuter. The code is formulated with real geometry using Miller's generalized $\hat{s} - \alpha$ local MHD equilibrium model [3]. Lagrangian continuum (fluid-like) numerical methods are used with a 5 dimensional grid $(n, r, \theta, \hat{\varepsilon}, \hat{\lambda})$ where n is the toroidal mode number, r is the midplane minor radius flux surface label, θ the poloidal angle $(-\pi, \pi)$, $\hat{\varepsilon}$ the temperature normalized energy ε/T, and $\hat{\lambda} = (\mu/\varepsilon)B(r, \theta = 0)$ with μ the magnetic moment. Linear implicit numerical techniques from Kotschenreuther's linear ballooning mode gyrokinetic code [4] allow the fast transit motion of the current carrying passing electrons to be passed over, thus permitting finite beta simulations up to the MHD critical beta. The code is programmed with the expensive Green's functions, and gyro-averaging matrices and inverted response matrices computed once and stored. The code is laid out for fast parallel processing with one radial grid per processor. A grid suitable for present day moderate ρ^* tokamaks fits on the T3E computer. Future terascale (100× faster) computers should allow high-n simulations at ITER ρ^* values or permit full torus simulations (n=0,10,20...100) → (n=1,2,3....100) to study interaction of small scale turbulence with low-n MHD modes.

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