Development of a Gyro-kinetic Vlasov Simulation Code for Boundary Plasmas*

X. Q. Xu and W. M. Nevins
Lawrence Livermore National Laboratory, CA 94550

A new development of an integrated kinetic simulation code is described to model the boundary region of tokamak fusion reactor plasmas in a realistic magnetic geometry. A kinetic treatment of the edge pedestal is required because the radial width of the pedestal observed in experiment is comparable to the radial width of individual particle orbits (leading to large distortions of the local distribution function from a Maxwellian), while the mean-free-path is long compared to the connection length in the hot plasma at the top of the edge pedestal and becomes short going toward the SOL. Compared to fluid models, the non-linear kinetic formulation we propose to develop adds two velocity-space dimensions to calculate the particle distribution function, which will significantly depart from a Maxwellian in the H-mode pedestal. A Fokker-Planck operator will be used to describe collisional velocity-space transport. This paper is a report on the formulation and numerical implementation of a non-linear kinetic treatment of edge turbulent transport. In particular, we will present a consistent set of equations to describe a kinetic edge plasma on the appropriate time scale while avoiding any ordering of the length-scale of the edge turbulence relative to the equilibrium, turbulence time-scales relative to the collision time. We will report the test results to compare the best available numerical scheme to solve parallel advection with electric acceleration in different coordinate representations in a realistic magnetic geometry. The progress on numerical implementation of Fokker-Planck operator will also discussed.

*This work was performed under the auspices of the USDoE by University of California Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.