Positivity Preservation and Advection Algorithm Tests for Edge Plasma Turbulence*

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Twenty Second International Conference on the Numerical Simulations of Plasmas
Long Branch, New Jersey, September, 2011

The unique conditions of edge tokamak plasmas motivate the employment of efficient numerical methods that can robustly handle steep temperature and density gradients. To that end, we compare an Arakawa finite difference technique with some recent high-resolution upwind methods that are designed to minimize non-monotonic overshoots while preserving the accuracy of solutions at smooth extrema. Versions of these algorithms are able to rigorously preserve positivity when that is physically relevant (such as for the advection of particle density or temperature). We discuss the use of these methods for the nonlinear Poisson bracket, an operator applicable to neutral fluid, gyrofluid, gyrokinetic, and general Hamiltonian simulations. For one-dimensional passive advection, the high-resolution upwind techniques maintain monotonicity and approach minimal levels of phase error and dissipation, especially at long-wavelengths. In a two-dimensional incompressible Navier-Stokes vortex merging problem we find that extrema-preserving methods can resolve details at lower resolution than the Arakawa technique, are less dissipative than traditional finite volume methods while still minimizing overshoots and ensuring positivity, and model nonlinear cascade behavior fairly well without additional subgrid damping. Some possible advantages of discontinuous Galerkin algorithms will also be discussed.

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*Supported by DOE Contract DE-AC02-09CH11466 (PPPL) and the DOE SciDAC Center for Multiscale Plasma Dynamics

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