Total-f Fully Nonlinear Electromagnetic Gyrokinetic Computation

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The tokamak edge layer is simulated using a total-f electromagnetic gyrokinetic field theory model based on an "MHD Lagrangian" designed to capture shear-Alfven (reduced) MHD and equilibrium flows on a banana width scale. At small scales it reduces to conventional form for small fluctuations. Full Hamiltonian support including conservation laws is rigorously maintained. A nonlinear collision operator is used. Conservation laws are computationally verified. The bracket structures are discretised with an Arakawa method, while the collision operator is finite-volume. The timestep uses the Karniadakis method. Without collisions, a "neoclassical control case" determines the necessary resolution to conserve energy/momentum and also produce negligible transport in the absence of collisions. With collisions the tokamak bootstrap current is found self consistently. Global geodesic shear Alfven oscillations are demonstrated to conserve energy and relax into the MHD equilbrium, whose divergence balances are contained within the model and the code. The code behind this is FEFI ("full electrons, full ions"). Ongoing attempts to establish it as a comprehensive equilibrium and turbulence model are described. The theoretical basis of gyro-drift averaging in the transonic flow limit is discussed.