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Title

Transition from delta-f to full-f PIC via an adaptive background using GK-engine.
(Update on MAGYK task WP2T1.D1)

Abstract

The gyrokinetic delta-f particle-in-cell (PIC) approach is known to be successful for simulating turbulence in the core of magnetic fusion plasmas, where fluctuations are relatively small and therefore the unperturbed particle distribution function, usually represented by a stationary Maxwellian f_0, remains a good choice of a control variate for reducing statistical sampling noise. However, towards the plasma edge, characterized by low density and temperature and strong gradients, relative deviation amplitudes typically become large, so that the essential assumption of $|\delta f/f_0| << 1$ underlying the delta-f PIC approach will not be valid, where δf is the fluctuating part of distribution. This motivates the study of the limits of the delta-f approach in a simplified system mimicking the plasma edge. To this end, simulations are run using GK-engine, which is a delta-f PIC code that solves the nonlinear gyrokinetic eqs in a sheared slab geometry, using B-spline finite elements to represent the self-consistent electrostatic field. Initial radial density and ion temperature profiles exhibiting high logarithmic gradients representing plasma edge conditions are used. In order to avoid practical problems of particles exiting the simulation domain as the ion temperature profile relaxes, all profiles are mirrored at domain-centre and periodic boundary conditions are imposed. The validity of the delta-f approach is measured by statistical noise estimates, while monitoring relative deviation levels of temperature via the kinetic energy. In particular, the effect of background profile gradients on these measures is investigated. As a first step towards reducing the amplitude of the deviation δf, an adaptive Maxwellian f_0 is implemented, whose time dependent temperature profiles are obtained by locally relaxing kinetic energy accumulating in δf into f_0. Current work on a radially dependent naive krook operator to further reduce noise will also be presented