Capabilities of the 3d BEPS3 PIC codes
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Introduction

The suite of codes in the directory mpbeps3 contains three separate main codes which share many functions. The electrostatic code mpbeps3 is the most simple, keeping only the Coulomb interaction between particles, with three position and three velocity components for the particles. The electromagnetic code mbbeps3 keeps the electric and magnetic fields described by the full set of Maxwell's equations. The Darwin code mdbeps3 keeps the electric and magnetic fields generated by particles (omitting light waves) described by the Darwin subset of Maxwell's equation where the transverse displacement current is omitted. The Darwin code can also be run as an electrostatic code by setting the speed of light to infinity. All codes can be run with relativistic equations of motion. The particle calculations are performed in parallel using OpenMP and MPI. If MPI is not available, the codes can be compiled with OpenMP only. Parameters to set various parameters in the code, described below, are described in the file input3mod.f90. All codes currently use periodic boundary conditions.

Initializations

The plasma density can be initialized with 6 different density profiles, including uniform, linear, sinusoidal, and gaussian profiles among others. The initial velocity distributions are Maxwellian for non-relativistic particles or Maxwell-Juttner momentum distributions for relativistic particles. Ring distributions are also supported. Both electrons and one species of ions are supported, and two populations of each species are possible (a background and a beam population). Different random number groups can be used for generating velocity/momentum distributions.

External Forces

A fixed constant external magnetic field can be used with the electromagnetic and Darwin codes. (The Darwin code can be run as an electrostatic code by setting the inverse speed of light ci to zero in the namelist input.) An external electric field with a fixed frequency and wavelength is also supported. Non-interacting particles are also possible, that is, they generate electric or magnetic fields, but do not respond to them.

Diagnostics

For the electrostatic code, 5 field diagnostics are possible: energy, electron and ion densities, potential, and longitudinal electric field. In addition, 4 particle diagnostics are possible: velocity/momentum distributions+ entropy, phase space, test particles and fluid moments. The electromagnetic and Darwin codes support the above diagnostics as well as 5 additional field diagnostics: electron and ion current, vector potential, transverse electric fields, and magnetic field. In addition, the electromagnetic code supports a radiative vector potential diagnostic specifically to look for light waves.

Other Features

In addition to these features, all the codes support restart capabilities to start a new run from where an earlier run left off. All the codes are time reversible., where a code can run forward for some time, then run back to the beginning. For the electrostatic and electromagnetic codes, round-off errors limit the accuracy of the time reversibility. The Darwin code uses an iterative scheme for solving the field equations, and this can also limit the time-reversibility. Compiler generated vectorization is now supported.

High level libraries and main scripts have been translated into Python to enable the main codes to be run interactively from Python. The Python scripts support OpenMP only.

Future Plans

Further develop high order libraries, non-periodic spectral field solvers, additional particle boundary conditions, higher order interpolations, parallel random number generators, and dynamic load balancing.