Diagnostics for a 3D Adaptive Mesh Refinement Hybrid PIC code

Context

Hybrid-PIC[1] codes are well suited to model cross-scales problems where the ions can be treated as macro-particles, while the electrons are modelled as a fluid. Such approach is of great interest to many problems in laboratory and astrophysical plasmas, where the electron temporal and spatial scales do not need to be resolved, while retaining a kinetic treatment of ions is necessary.

In this internship, the student will be part of the team working on the code development project PHARE funded by the Labex Plas@par. This multi-laboratory (LPP, LERMA, LULI, ONERA, ICSD) collaboration aims at developing the next generation of massively-parallel, adaptive mesh hybrid Particle-In-Cell code for the modelling of laboratory and astrophysical plasmas. The goal is to have excellent parallel scaling over several 10k cores. To tackle this problem, we are planning to rely on an external Adaptive Mesh Refinement (AMR) C++ library (SAMRAI) which scales efficiently over a million cores.
The code is written in C++11 and its architecture is based on standard design patterns. The development involves a team of researchers. It follows code review, unit testing (using google test API), and continuous integration, to ensure code quality.

Objectives of the internship

The goal of this internship is to develop a module in the code for writing simulation outputs. Field and particle output will be considered with various time and spatial sampling strategies. The code will ultimately let the user choose the file format (either HDF5, OpenPMD etc.). Therefore several CoDecs have to be implemented according to a common abstract diagnostic interface. The student will work on implementing one concrete codec (for instance the HDF5 codec). The codec will be developed and benchmarked to ensure good parallel scalability and performances.
Depending on the course of the internship, the student will also work on 3D visualisation using the Visit tool and writing python scripts relying on Visit module to produce specific 1D and 2D integrated simulation diagnostics.

Candidate profile

The successful candidate :

- knows C++ programming language, OOP and design patterns
- has a good knowledge of interpreted language Python
- is familiar with physics/mathematics
- is strongly motivated by high performance computing
- is autonomous, rigorous

Duration : 6 months maximum

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[1] Particle-In-Cell (PIC) codes simulate the behaviour of a large number of physical particles by using a smaller set of "macro-particles" with similar statistical properties. PIC descriptions are widely used in plasma physics when the kinetic aspect of the plasma must be captured. Examples are non-Maxwellian distribution functions, particle acceleration, Landau damping and cyclotron resonances.

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