بسم الله الرحمن الرحيم

AECENAR
Association for Economical and Technological Cooperation in the Euro-Asian and North-African Region

IAP INSTITUTE FOR ASTROPHYSICS

Particle simulation code (PSC - Plasma)

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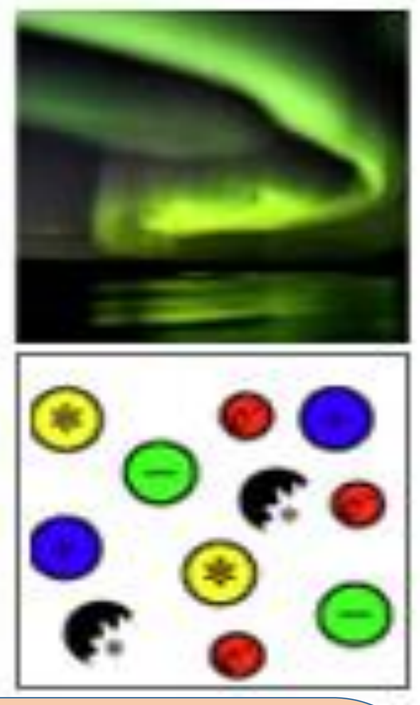
Principles

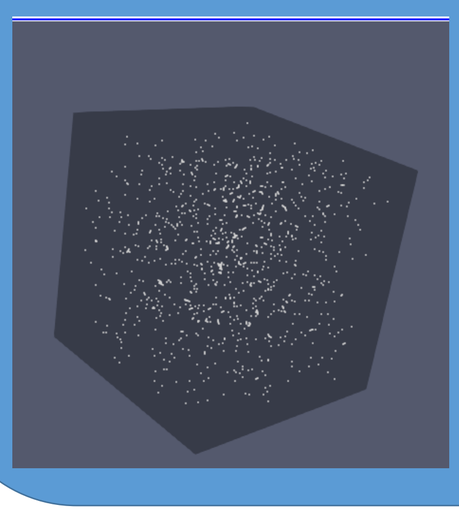
Plasma is considered the fourth state of matter. Plasma is a cloud of protons, neutrons and electrons where all the electrons have come loose from their respective molecules and atoms, giving the plasma the ability to act as a whole rather than as a bunch of atoms.

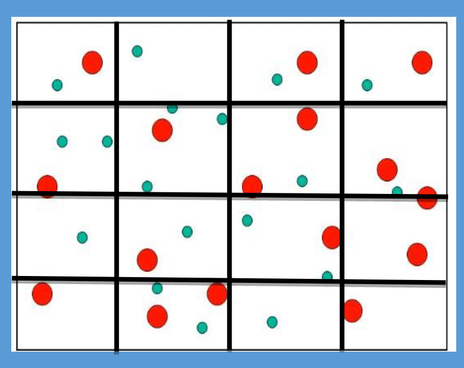
The governing equations of intense laser plasma interaction, are the Vlasov-Boltzmann equations combined with Maxwell's equations in three spatial and momentum dimensions



Meshing

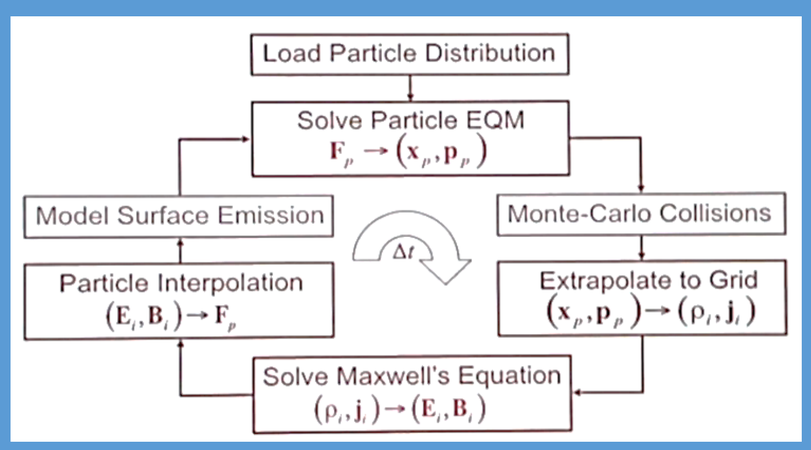
The geometry used in this program is a cube. 1000 particles were studied (500 electrons and 500 ions) distributed randomly in the box.





Equations

The sequence followed in our program is:



Using these equations:

- Lorentz force:

- Lorentz-Force: $\mathbf{F}_p = q\mathbf{E}_p + \frac{q}{m}(\mathbf{p}_p \times \mathbf{B}_p)$

Position and velocity:

$$\frac{d\vec{v}_j}{dt} = \frac{q_j}{m_j}(\vec{E} + \frac{\vec{v}_j \times \vec{B}}{c})$$

$$\frac{d\vec{x}}{dt} = \vec{v}$$

Density and current:

$$\rho(\vec{x}) = \sum_j q_j \delta(\vec{x} - \vec{x}_j)$$

$$\vec{j}(\vec{x}) = \sum_j q_j \vec{v}_j \delta(\vec{x} - \vec{x}_j)$$

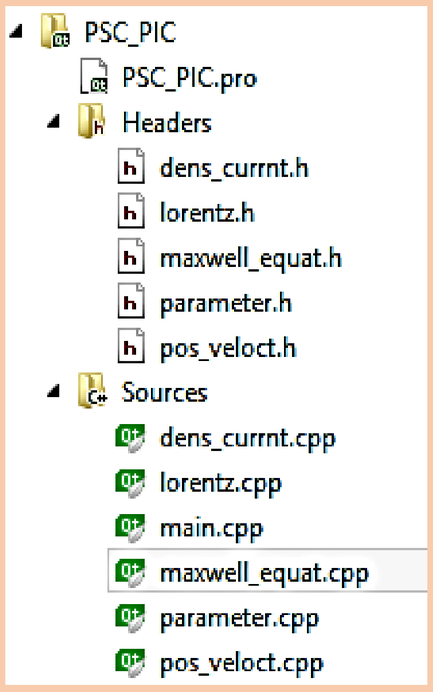
Maxwell equations to calculate E and B

$$\nabla \times \vec{E} = -\frac{1}{c}\frac{\partial \vec{B}}{\partial t}$$

$$\nabla \cdot \vec{B} = 0, \quad \nabla \cdot \vec{E} = 4\pi\rho$$

$$\nabla \times \vec{B} = \frac{4\pi\vec{j}}{c} + \frac{1}{c}\frac{\partial \vec{E}}{\partial t}$$

Program

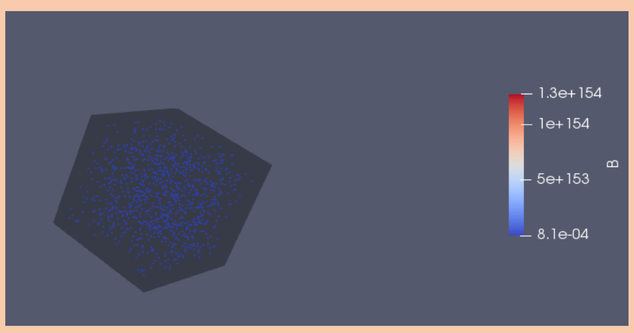


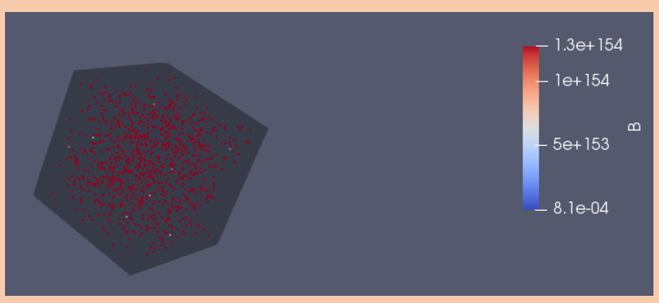
The program is composed from 5 classes and the main program.

After initializing the parameters and the initial condition using the class << **parameter.cpp** >>, the Lorentz force on each particle is calculated using the class **<< Lorentz.cpp>>** then the new position and the velocity is calculated using the class << **pos_veloct.cpp** >>. The density and the current on the grid are calculated using the class << **dens_currnt.c**pp>>. Using these values and the Maxwell equations, the electric and magnetic field are calculated on each cell using the class << **Maxwell_equat.cpp** >>. Now the Lorentz force is recalculated and a new time step starts.

Results

we can present any variable we want: velocity, electric field or magnetic field. The pictures below present the variation of the magnetic field with time. The magnetic field vary from time step to another as we can see in the pictures





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