§32. Development of In Situ Visualization Tool for PIC Simulation

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As the ability of computer is being greatly improved year after year, the size of computer simulation is becoming larger and larger. This causes new challenge to visualization for large scale simulations, which simulation researchers have to face. Traditionally, the visualization of simulation results is carried out after computer simulations on researchers' PCs by using interactive visualization software. However, for the case of large scale simulations it is becoming almost impossible to perform interactive visualization on PCs. There are several reasons why it is. For example, it takes too much time to transfer the data from the storages of supercomputers to those of PCs via network, and the size of data is too big to handle for PCs.

A promising way to overcome this difficulty is in situ visualization, a way of visualization. For the case of in situ visualization, visualization code is embedded in simulation code and visualization is carried out along with computer simulation on the same supercomputer. The embedded visualization code does not save raw large scale data but visualization image files. It is clear that this way of visualization has advantages. It has also disadvantages of not being able to perform interactive visualization because visualization is done as a batch process.

We developed an in situ visualization tool for PIC (particle-in-cell) simulation[1], VISMO. It is provided as a Fortran's module. The target PIC simulation code is three-dimensional and parallelized based on domain decomposition method by at least MPI. If the PIC code is parallelized by MPI/OpenMP hybrid scheme, VISMO works in the same way. Table 1 shows the incorporated visualization methods of VISMO. All the methods are implemented by software rendering and do not require graphics hardware. This means that VISMO can be used on ordinary supercomputers.

Table 1. VISMO's visualization methods

Data	Methods
Particles (ions and electrons)	Sphere Rendering
Scalar Field	Isosurface Color Slice Volume Rendering
Vector Field	Stream Lines Arrows

We coupled VISMO with PASMO[2] and tested the coupled code on Plasma Simulator supercomputer (Hitachi SR16000 Model M1, POWER7) at NIFS in Japan. The size of domain is 514×257×130. PASMO uses 64 MPI process and 32 threads for a MPI process. Therefore, 2,048 CPU cores are also used by the coupled code. The coupled code successfully visualized the data in situ by directly accessing the data arrays and visualization image files were obtained. Fig 1 and 2 are images obtained by the coupled code.

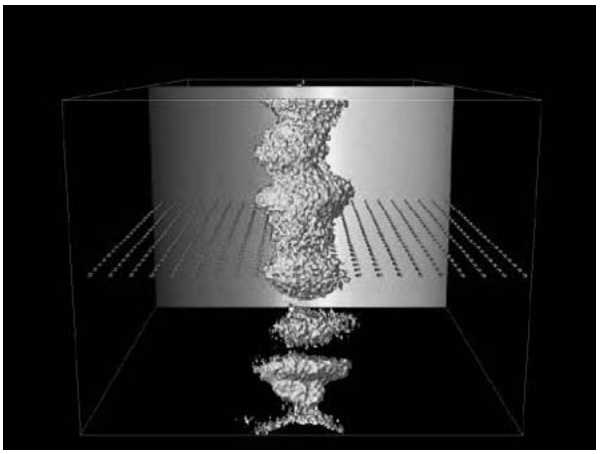

Fig 1. Color slice, arrows and isosurface show the magnitude of x-component of magnetic field, magnetic field and density of electrons respectively.

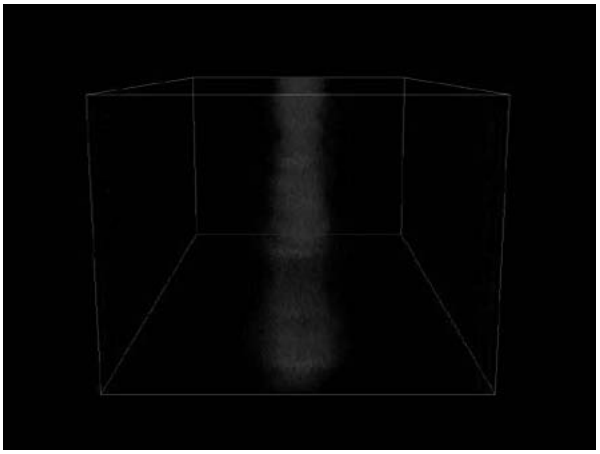

Fig 2. Density of electrons is visualized by volume rendering.

Our future work is working out an efficient way of in situ visualization using this coupled code.

1) C. K. Birdsall and A. B. Langdon: Plasma Physics Via Computer Simulation, McGraw-Hill, New York (1985).
2) H. Ohtani and R. Horiuchi: Plasma Fusion Res. 4 (2009) 024.