§25. Development of PASMO Code and in-situ Visualization Library VISMO

Ohtani, H., Ohno, N., Horiuchi, R., Usami, S.

Magnetic reconnection is widely considered to play an important role in energetically active phenomena in high-temperature plasmas. In spite of intensive research, many basic questions on the details of the mechanisms of reconnection still remain poorly understood. To clarify the relationship between particle kinetic effects and anomalous resistivity due to plasma instabilities in the reconnection phenomena, we have been developing a three-dimensional particle simulation code for an open system, called PASMO [1,2,3]. On the other hand, the highly increased computational capability of super computers enables us to perform large-scale simulations. However, when the researchers visualize and analyze them, the hugeness of simulation results causes difficulties in storing them on the storage system, transferring them from supercomputer sites to the local researchers' computer system and visualizing them on the local smaller computer system compared to the supercomputer system. In order to solve these problems, in-situ visualization is one of the effective methods. We are developing an in-situ visualization library VISMO [4].

We optimized PASMO, which was parallelized by three-dimensional domain decomposition, to port to FX100. We parallelized the parts, in which the compiler could not parallelize automatically, by OpenMP to use thread-level parallelism. As a result, we achieved a seven-times performance improvement compared with before optimization. However, since the parts with the highest cost, in which the equations of motion of particles were solved and the current density was calculated from the positions of particles, were complicated and large, they were not optimized by SIMD data processing and software pipeline. In order to improve the performance of PASMO furthermore, we have to reconsider the algorithm itself of the pusher and gather parts of PASMO.

We examined the introduction of OhHelp library [5] to PASMO code. In the magnetic reconnection, the particle distribution is not uniform spatially. If PIC simulation code is parallelized by the domain decomposition, in which the domain is decomposed by the same size boxes, the numbers of particles in the boxes are greatly different from one another and the computational load balance becomes wrong. OhHelp library proposes a parallelization method which can redress load imbalance due to the imbalance of the particle distribution.

We advanced the development of the in-situ visualization library VISMO and investigated pseudo interactive visualization by point clouds. In-situ visualization has some disadvantages to be improved. 1) Since a visualization process is added to the simulation execution, the simulation performance needs longer time than the simulation without in-situ visualization. 2) It is impossible to visualize the data interactively, because the simulation data are not left in the in-situ visualization. 3) Computer simulations, including the combined programs, are carried out as bat jobs so that in-situ visualization is not interactive by nature. We developed a method which enables us to overlook the simulation data from many viewpoints, to combine several visualization techniques [6]. Figure 1 shows one example of the visualization of test data by using a special viewer based on Kyoto Visualization System library [7]. Streamline and arrow of vector field, and isosurface and contour of scalar field are shown together.

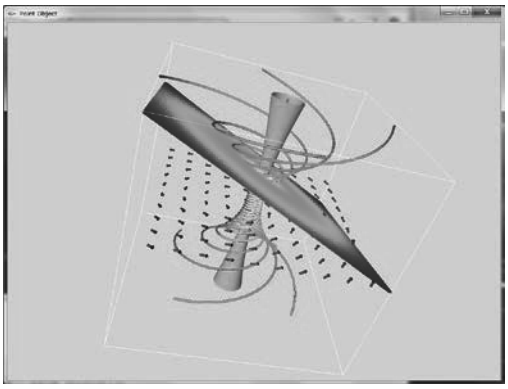

Fig.1. In-situ visualization of test data.

We have a plan to develop the open boundary condition suited for the domain decomposition parallelization algorithm and to perform large-scale particle simulation to investigate the magnetic reconnection. In the simulation, we will apply the VISMO to visualize the results.

1) Horiuchi, R. et al: Phys. Plasmas **6** (1999) 4565.
2) Ohtani, H. et al: LNCL **4759** (2008) 329.
3) Ohtani, H. and R. Horiuchi: PFR **4** (2009) 024.
4) Ohno, N. and Ohtani, H.: PFR **9** (2014) 3401071.
5) Nakashima, H. et al: Proc. Intl. Conf. Supercomputing, pp. 90-99, June 2009.
6) Ohno, N. and Ohtani, H.: The 6th AICS International Symposium, February 22-23, 2016, (Kobe, Japan)
7) Sakamoto, H.: "Kyoto Visualization System", available at https://github.com/naohisas/KVS (accessed 14 September 2015).