§4. Development of PASMO Code

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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].

PASMO code was parallelized in one-dimension direction (the direction is along the current direction. In the decomposed domain, the dynamics of particles and electromagnetic fields are controlled by one MPI process). In the 2014 fiscal year, we decomposed the simulation box three-dimensionally with the periodic boundary condition and checked the performance. The strong scaling showed that the performance became worth when the number of the MPI processes increased, because the correction calculation by solving the Poisson equation, which modified the microscopic inconsistencies between current and charge densities due to use of the mesh and weights [4], needed the global calculation such as FFT. In order to perform the large-scale particle simulations on a massive parallel computer system, we need to exclude such global calculation with keeping the high accuracy. We adopt the exact charge conservation method [5] in this fiscal year. This method calculates the current density with implementing the equation of continuity instead of solving the Poisson solver. By performing the PASMO code with this method, it is found that the conservation law of energy is kept with higher accuracy and the difference between the divergence of the electric field and the charge density is smaller than the conventional method with solving the Poisson equation (Fig.1). Moreover, we adopt the bucket sorting method for the particle index in order to use the cache memory effectively in the pusher and gather processes. The strong scaling of the new PASMO code with the periodic boundary condition is shown in Fig.2 for the comparison with three algorithms (the conventional method with the Poisson solver, the Esirkepov method, and the Esirkepov method with the bucket sorting). Because the scaling of the conventional method is worth than the others, the method cannot be used on the massively parallel computers. The Esirkepov method with the bucket sorting algorithm shows better strong scaling than others.

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.

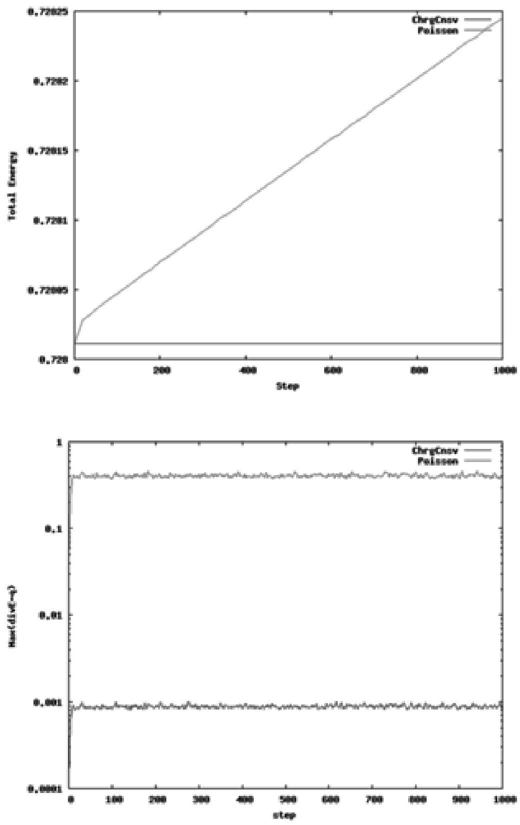

Fig.1 Energy conservation (top) and the difference between the divergence of the electric field and the charge density.

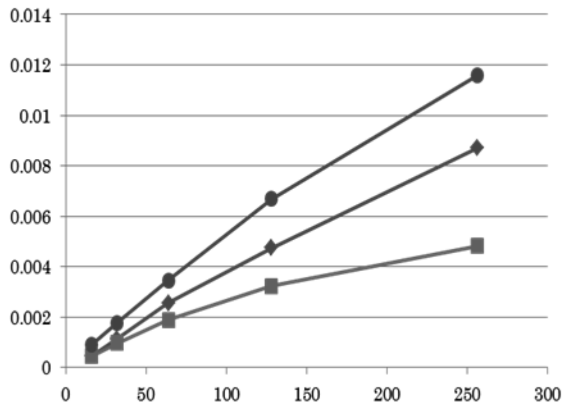

Fig.2. Performance of the code. Vertical and horizontal axes show inverses of calculation times and number of MPI processes, respectively. Square, diamond and circle show the conventional method, Esirkepov method and Esirkepov with the bucket sorting, respectively.

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2) Ohtani, H. et al: LNCL **4759** (2008) 329.
3) Ohtani, H. and R. Horiuchi: PFR **4** (2009) 024.
4) Birdsall C.K. and Langdon, A.B.: Plasma Physics via Computer Simulation (IOP Publishing Ltd, 1991).
5) Esirkepov, T.Zh.: CPC **135** (2001) 144.