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Combination of particle-in-cell simulation with analysis by in-situ and virtual-reality visualization for investigation of plasma physics

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We have developed a particle-in-cell plasma simulation code "PASMO" [1] to investigate magnetic reconnection in an open system. By using the PASMO code, we investigated the influence of a guide field on collisionless driven reconnection [2], the effective heating of nonadiabatic protons in magnetic reconnection with a guide field [3], and so on. Moreover, we applied scientific visualization by the CAVE-type virtual-reality (VR) system [4] to the analysis of magnetic reconnection simulation data [5, 6]. In these VR visualization, we clarified the relationship between complex three-dimensional structures of magnetic field, distribution of particle temperature and particle trajectories. We also realized the integrally VR visualization of the experimental observed data with the results of the equilibrium plasma simulation in the vessel device CAD data using the VR system [7]. The experiment data was observed from only outer observation port, but by using the VR system, we can watch the data from any view point. We can analyze the three-dimensional structure, and compare it with the simulation results directly.

Since computer technology is achieving rapidly-advancing development these days, larger-scale simulations by PASMO can be performed and more detail analysis by VR system is expected. However, VR visualization analysis cannot deal with all the spatiotemporal simulation data because the simulation run cannot store all the simulation results due to the limitation of the storage system. In order to resolve this problem, we are developing an in-situ visualization library "VISMO" [8], which generates and stores figures visualizing the simulation results instead of the simulation raw data together with simulation run. The VISMO furthermore has the function to output point clouds which have three-dimensional information of the visualized objects, and the viewer software to reconstruct three-dimensionally the point clouds for representing the objects. The viewer software can also show the objects in the VR world by the CAVE-type system. The reconstructed objects can be seen interactively from all the viewpoints.

Since VISMO can visualize all the spatiotemporal simulation data, it will be possible to specify when and where the important events take place in the simulation. The PASMO code with VISMO is also used for investigating the turbulence in collisionless plasmas in our ongoing work. Figure 1 shows the isosurface of $\nabla \times B$ at the initial time at the initial time. In this work, we study the kinetic effects in the turbulence, and compare the effects with the magnetohydrodynamics simulation. By combine the event searching with the in-situ and VR visualization, it is possible to analysis interactively the turbulence phenomena. It is expected to improve the productivity of the simulation researches.

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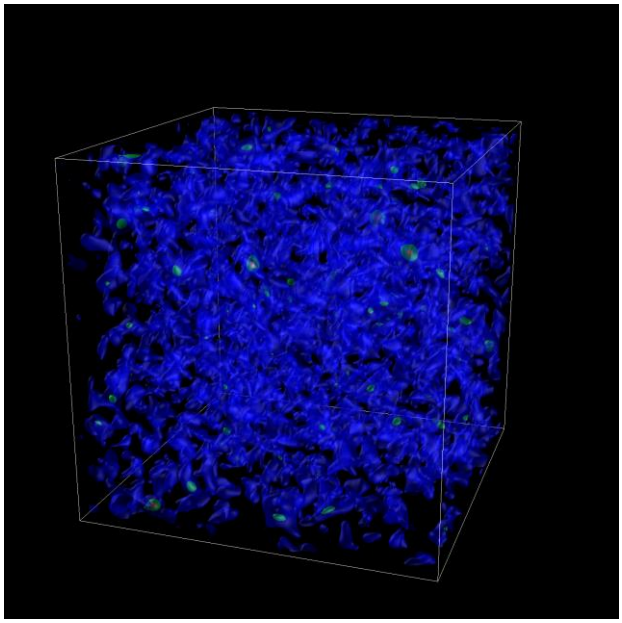

Figure 1: Isosurface of $\nabla \times B$ at the initial time.