## §29. Analysis of Dynamics of Reconnection Simulation Data by VR System

Ohtani, H., Ohno, N. (Univ. Hyogo)

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 about the details of 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 develop a three-dimensional particle simulation code for an open system, called "PASMO" [1-3].

Because this effect is originating from a complex thermal motion near reconnection point, it is very important to examine particle trajectories using scientific visualization technique, especially in the presence of plasma instability. We developed software for visualizing particle trajectories in electromagnetic fields on snap shot data based on VFIVE, which is interactive visualization software for the CAVE system [4]. In the analysis of the magnetic reconnection, we clearly displayed the relationship between the complex 3D structures of magnetic fields, flow velocity of ion, distribution of ion temperature and ion trajectories in the VR space, and found that non-thermal motion of ions strongly related to the heating process of the magnetic reconnection.

Furthermore, plasma instabilities are also found to be excited in the reconnection region, and influence on the particle kinetic effects by modifying the particle trajectories. Thus, particle trajectories in the time-varying electromagnetic fields are important keys for understanding the role of the particle kinetic effect in collisionless reconnection.

In this paper, we have extended the VFIVE to be able to handle time-varying data and visualize the trajectories of particles in time-varying electromagnetic fields. This extension is realized as the animation function to the VFIVE [5].

First of all, user prepares time sequential data of electromagnetic fields, flow velocity, temperature and so on, which are the result of simulation and put all of them onto a HDD. In this method, the electromagnetic field data are read by VFIVE as the data set of the current and the next steps from a HDD, and are interpolated linearly between the two steps. Newton-Lorentz equations are solved to calculate the trajectories of particles in the interpolated fields. After this integration, VFIVE read the next-step field data again.

Figures 1 and fig:2 show one snap shots of analysis of reconnection simulation resutls by virtual-reality system. Since the data is time-sequential, this figure is a snap-shot of animated graphics. We can investigate the dynamics of plasma from any view-point which we want to watch, and enlarge and reduce the objects in the immersive 3D space with the interactiveness. It is possible to observe that magnetic island is excited near the reconnection point, the magnetic field line winds around the island, and the particle bounces the island.

By adding the method for visualizing the trajectories of ions in time-varying electromagnetic fields to VFIVE, researchers can investigate the relationship between the trajectories of ions and other physical quantities in the CAVE room interactively and intuitively. We believe that this development will enhance the study of the phenomena in high temperature plasma such as collisionless magnetic reconnection.

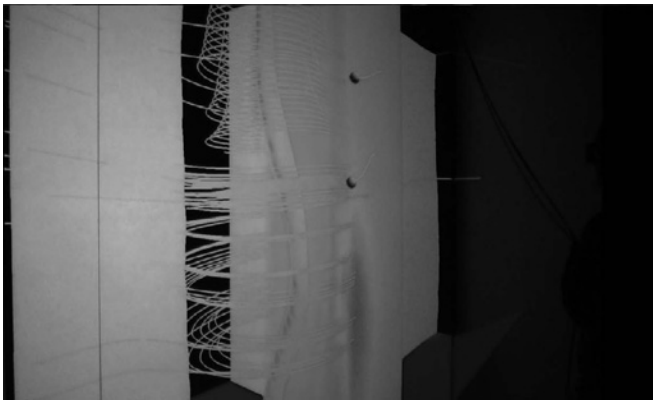

Fig. 1. One snap shot of analysis of reconnection simulation resutls by virtual-reality system. Since the data is time-sequential, this figure is a snap-shot of animated graphics. We can investigate the dynamics of plasma from any view-point which we want to watch, and enlarge and reduce the objects in the immersive 3D space with the interactiveness.

Fig. 2. The same figure as Fig. 1 but from the different view point.


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) Ohtani, H. and Horiuchi, R.: PFR **3** (2008) 054.
5) Ohno, N., Ohtani, H., Matsuoka, D. and Horiuchi, R.: PFR **7** (2012) 1401001.