

### §30. Virtual Reality Analysis of Particle Trajectories in Magnetic Reconnection

Ohtani, H., Ohno, N. (Earth Simulator), Horiuchi, R.

Magnetic reconnection is widely considered to play an important role in energetically active phenomena in high temperature plasmas. Ions become un-magnetized and execute a complex thermal motion called meandering in the ion dissipation region. The complex meandering motion leads to the growth of off-diagonal components of the pressure tensor term, which is one of main causes to break ion frozen-in condition in the vicinity of magnetic neutral sheet [1-3]. On the other hand, plasma instability is excited near the reconnection region [4,5]. It is important to clarify the relationship between the role of meandering particles and physical quantities such as temperature and magnetic field structure in the temporally evolving fields in order to understand the magnetic reconnection phenomenon. In this paper, we propose a four-dimensional analysis method for simulation data in interactive visualization environment by the CAVE virtual reality (VR) system based on VFIVE, which is interactive visualization software for the CAVE system.

Simulation data of a collisionless driven reconnection is obtained by the 3-D PArTicle Simulation code for Magnetic reconnection in an Open system (PASMO) [6].

To analysis the particle trajectories in the time-sequential electromagnetic field obtained by PASMO, we improve and advance VFIVE (Virtual Reality Visualization Software for CAVE Systems) to trace the trajectories of plasma particles in the temporally evolving in the VR world [7,8]. VFIVE is one of the general purpose VR visualization softwares developed by Kageyama and Ohno [9]. This software can show the vector fields as lines, arrows and so on, and the scalar fields as isosurface, contour and volume rendering. We add animation function to the VFIVE to handle time-sequential data.

Figures 1 and 2 display time-constant data and time-sequential data cases, respectively. A periodic boundary condition is imposed along  $z$  direction for dynamics of particles and field. In Figs. 1 and 2, particle 1 goes out through  $z$  boundary from the simulation box and enters into the simulation box (particle 1') through  $z$  boundary again. The trajectory in the snap-shot data case of particle 2, which directly moves from the periphery of the reconnection region to the downstream region, is almost the same as that in the time-sequential data case. On the other hand, particle 1 in the time-constant data case moves in the periphery of the reconnection region along  $-z$  direction, passes through the  $z$  boundary, and then (particle 1') goes toward the downstream ( $x$  direction). However, particle 1 in the time-sequential data case moves slightly toward the downstream with passing through the periphery of the reconnection region. After passing through the  $z$  boundary, it (particle 1') goes out the downstream boundary. That is, the particle in the time-sequential data case moves faster toward the

downstream than that in the time-constant data case. This result suggest that acceleration mechanics works on particles along the downstream direction ( $x$  direction) while they pass the reconnection region, where the field changes in time.

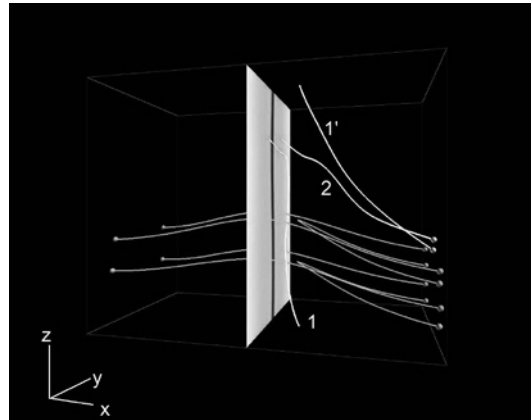


Fig. 1. CAVE visualization of snap-shot data of magnetic reconnection simulation. Blue and white lines are magnetic field stream lines and ion trajectories, respectively. Blue and red balls indicate the downstream and upstream of stream lines, respectively. Green isosurface shows the high temperature region of ion. Color contour on  $yz$  planes displays reconnection component of magnetic field ( $B_x^2 + B_y^2$ ).

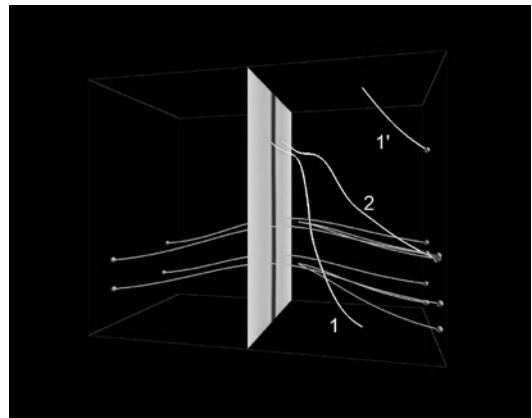


Fig. 2. The same figure as figure 1 but time-sequential data.

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