§27. 3D Scientific Visualization by the CompleXcope CAVE System

Kageyama, A., Sato, T.

With the advance of the supercomputers, the simulation science has been matured. Physics researchers today are investigating complex (three-dimensional and dynamical) phenomena by advanced computer simulation methods. Since structures to be visualized in such simulation data are highly complex, the CRT-based scientific visualization is no more useful. Fortunately, the recent development of virtual reality (VR) technology gives a powerful research environment for a three-dimensional scientific visualization/analysis. In 1997, we installed a CAVE VR system and named it *CompleXcope*. The CAVE is the pioneer of projection based, room-sized VR system developed at Electronic Visualization Laboratory (EVL), University of Illinois at Chicago [1]. CompleXcope has 3 soft screens for the walls and 1 hard screen for the floor. The screen size is 10 foot × 10 foot. The images are generated by a graphic workstation (SGI ONYX2). The stereo color images are projected by 4 projectors with 4 mirrors. The wall screen images are rear-projected and the floor screen image is projected from a ceiling-mounted projector. A magnetic tracking system is used for the real-time detection of spatial position/direction of liquid crystal shutter stereo glasses and a 3D mouse, called wand. The wand is a portable controller with three buttons and a joystick.

We developed several CompleXcope application programs. One of them is called the Virtual LHD which is to visualize/analyze MHD simulation data by the HINT code. The Virtual LHD has (1) A pair of helical coils, (2) Vacuum vessel, (3) Interactive magnetic field line tracing, (4) Interactive ion motion tracing, (5) Isosurface rendering of the plasma pressure and interactive control of its level. (6) Virtual ground, (7) Various menus and message boards for the interface. Researchers can walk in the CompleXcope room (of 10 × 10 foot floor) to observe 3D objects (helical coils, magnetic field lines, ion motion and orbit and so on) from any position and direction. They can stand even just inside the (virtual) LHD device. Pressing a wand's button starts a magnetic filed line tracing from the position of the wand's tip. Therefore, a researcher can understand complicated 3D magnetic field structure by placing his/her hand at the position of his/her interest and pressing the wand's button many times there. Pressing other button of the wand starts the tracing of ion motion (integration of drift equation) from that position. The initial condition of the pitch angle is also intuitively controled by the wand's direction. The researcher can observe that the ion is moving under his/her nose. Zigzag motion of a trapped ion is especially impressive (Fig. 1). The plasma pressure's isosurface is also shown and its level is interactively controllable in the CompleXcope room.

Another example of our VR scientific visualization is for a dynamo simulation in the rectangular geometry. Many fluid particles and magnetic field lines are interactively started to visualize the velocity and magnetic field structures of the simulation data. Owing to the interactive environment of the CompleXcope, researchers can "follow" a fluid particle motion in the CompleXcope room. When a particle show an interesting behavior, they can place their hands there and starts many magnetic field lines and other fluid particles by pressing the wand buttons many times around the point. (Fig. 2). Details of the CompleXcope is reported in [2].

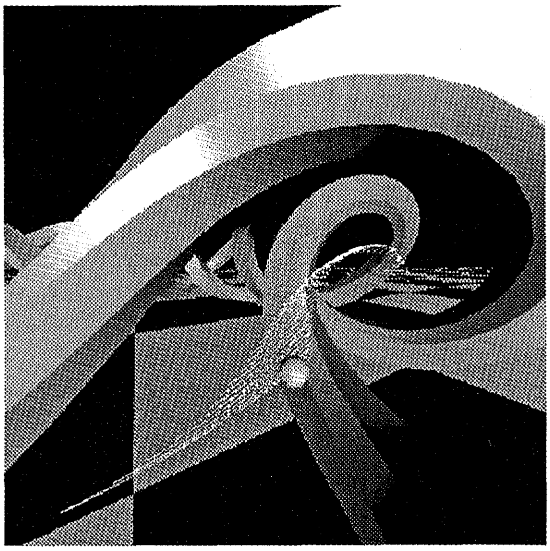

Figure 1: Trapped ion motion in the Virtual LHD

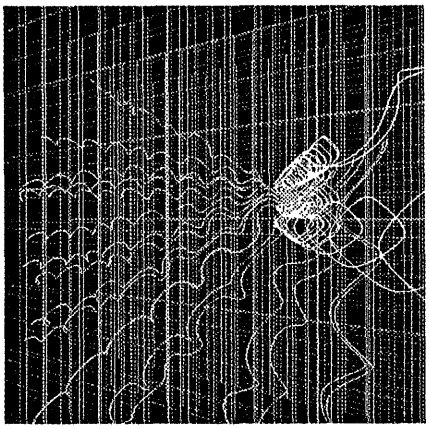

Figure 2: VR analysis of a dynamo simulation

References

1) C. Cruz-Neira, D. J. Sandin and T. A. DeFanti, Proceedings of *SIGGRAPH '93*, pp.135–142

2) A. Kageyama, Y. Tamura and T. Sato, submitted to Transactions of the Virtual Reality Society of Japan