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Application of Visualization by Virtual-Reality Technology to Plasma Physics
バーチャルリアリティ技術による可視化のプラズマ物理研究への応用

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We report recent progress of virtual-reality (VR) visualization in The National Institute for Fusion Science, Japan. In the integrated VR visualization, simulation results are shown in the experimental device data with an objective description in the one VR space. The interactive visualization environment for tracing particle trajectory in the time-varying field is adopted to investigate the role of particle kinetic effects in the collisionless magnetic reconnection. VR technology is an extremely useful tool in the analysis of simulation data and the development of experimental devices.

1. Introduction

In1997, the National Institute for Fusion Science (NIFS), Japan, installed the CompleXcope virtual-reality (VR) System based on CAVE system [1] as an instrument for scientifically analyzing simulation results. NIFS has developed new software including VFIVE, AVS for CAVE, a sonification system, and a reactor design aid tool. Through the use of these new tools, CompleXcope was adapted for scientific investigations, such as analysis of magnetohydrodynamics (MHD) simulation results for MHD dynamo and spherical tokamak, analysis of molecular dynamics simulation results for chemical sputtering of plasma particle on a diverter, and analysis of particle simulation for magnetic reconnection. In this paper, we report recent progresses of VR visualization.

2. Visualization results

2-1. Integrated VR visualization

For scientific VR visualization using CompleXcope system, we construct an approach method to display both simulation results and experimental device data integratedly in the VR world [2,3].

The magnetichydrodynamic (MHD) equilibrium simulation code “HINT” produces the equilibrium plasma of the Large Helical Device (LHD) [4]. The visualization software “Virtual-LHD” visualizes the isosurface of a plasma pressure, streamline of magnetic field, and the orbit of drift particle in the VR space [5]. The three-dimensional mouse “Wand” determines interactively the isosurface level, the initial point of the streamline, and the initial position and pitch angle in the VR space.

Experimental device data (LHD vessel) based on the CAD data is visualized by commercially available software with an objective description in the VR space.

It is difficult so far to visualize the objects by different visualization software in one VR space. However, new technology can capture the OpenGL data by the multiple software, and combine them into one data in one VR space [6,7].

Figures 1 show the initial positions of particles, and the snap shot of drifting particles, respectively, with a single magnetic field stream line. You can observe trapped and un-trapped particles simultaneously.

Image of plasma simulation results in an experimental vessel device in VR space has been

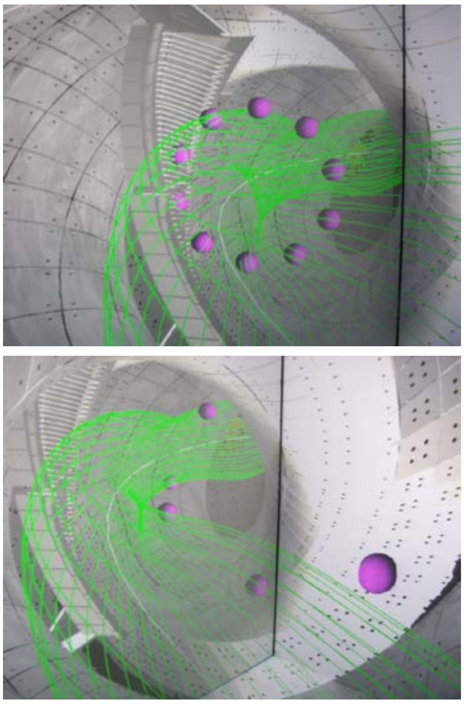

Fig. 1: VR visualization. Top figure shows the initial position of particles, and bottom shows the snap shot of drifting particles. Green line shows one single streamline of magnetic field.

presented with objectively description. This success indicates the possibility of intuitively understanding the physics of plasma, of aiding in the design and arrangement of the devices and of confirming the field of vision from the observation port in VR space.

2-2. Analysis of simulation results by VR visualization

Interactive visualization environment for the particle trajectories in time-varying electromagnetic fields by VR system [8] is developed based on VFIVE, which visualizes vector fields by streamline, arrows and so on, and scalar fields by isosurface, volume rendering and so on of simulation results interactively in VR space [9-12]. In order to understand the role of the particle kinetic effects in the collisionless magnetic reconnection, we adopt this new environment and find that the trajectories of particles in time-varying electromagnetic fields are different from that in time-constant data.

3. Summary

VR technology is an extremely useful tool in the analysis of simulation data and the development of experimental devices. We believe that the advances introduced in this paper will enhance the study of the phenomena of plasma physics and fusion plasmas, contributing to future research.

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