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Integrated visualization of dust trajectories and equilibrium plasma simulation data by virtual-reality system

バーチャルリアリティ装置によるダスト軌道と平衡プラズマシミュレーションデータの同時可視化

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Dust is one of the important key factors in determining the confinement profile of fusion plasma. In order to analyze the three-dimensional relationship between the dust trajectories and the magnetic-field structure, we develop the environment in which the time-sequence data of three-dimensional dust positions by the stereoscopic cameras in the Large Helical Device (LHD) experiments is visualized with the results of the equilibrium LHD plasma simulation by HINT2 code in the LHD vessel integrally by the virtual-reality (VR) system.

1. Introduction

Dust is one of the important key factors in determining the confinement profile of fusion plasma. In order to observe the three-dimensional (3D) trajectories of dusts, the stereoscopic fast framing cameras were installed in Large Helical Device (LHD), and it was possible to obtain the dust trajectories as time-sequence data of 3D positions by using the stereoscopic image data [1]. From the observation result, the typical dusts were transported along the magnetic-field lines, but some dusts moved radially across the lines with sharply curved trajectories. Recently, Shoji et al. investigated the function of the peripheral plasma in the LHD on transport of dusts by using a dust transport simulation code in a non-axisymmetric geometry [2]. They showed that the transport of the dusts was dominated by the plasma flow in the peripheral plasma. When we three-dimensionally analyze the relationship between the dust trajectories and the magnetic field structure or the plasma flow pattern, it is difficult to grasp it on the two-dimensional display, because they are projected on the two-dimensional space and the information of depth is lost. In order to solve this problem, it is useful to use the virtual-reality (VR) system [3], because it can give a user a deep absorption into the VR world by stereo-view system, tracking system and so on. In order to analyze three-dimensionally the relationship between the dust trajectories and the magnetic-field structure, we develop the system in which the time-sequence data of three-dimensional dust positions is visualized with the results of equilibrium LHD plasma simulation by HINT2 code [4,5] in the LHD vessel integrally by the virtual-reality (VR) system [6,7]. In this paper, we show several examples of the integrated VR visualization.

2. VR system and software

The VR system, CompleXcope, of National Institute for Fusion Science is based on the CAVE system [3]. We make an interface of reading the data and a function visualizing the dust trajectory in the VR space, and implement them to the VR

software, Virtual LHD [8], which calculates and visualizes in the VR space isosurface of plasma pressure, a streamline of magnetic field and a trajectory of drift particle of an equilibrium LHD plasma simulation results by HINT2 codes [4,5]. The experimentally observed positions of dusts are presented as balls by point-sprite method [9], and the trajectories are shown as several different colored lines to identify each trajectory. The LHD experimental device data is visualized by the commercial software, Virtools. The visualized objects by these software are combined and visualized integrally in the one VR space by the commercial software, FusionSDK [10,11].

3. Integrated VR visualization

The integrated visualizations of the time-sequential data of the dust, the plasma simulation result and the inner surface of the vacuum vessel are shown in Figs.1, 2 and 3. Figures show that the dust particles are located near the ICRF antenna and the closed divertor plate. It is considered that they are generated and flies from there. Two magnetic-field lines are also shown in green and red near the core and in the periphery, respectively. Since only one field line colored by red is shown, it is difficult to recognize the structure. How to visualize such vector field is a future work.

4. Conclusions

We made an interface of reading the experimental observation results of the dust particle trajectories and visualized them with the streamline of magnetic field of the equilibrium LHD plasma simulation result in the LHD vessel with objective description in CompleXcope. It is possible to observe the trajectories from every direction and grasp the three-dimensional relation with the devices. It is confirmed that VR technology is powerful equipment for analyzing the experimental observation results. We believe that the buildup in this paper will boost up the research of the plasma physics and fusion plasmas.

Acknowledgments

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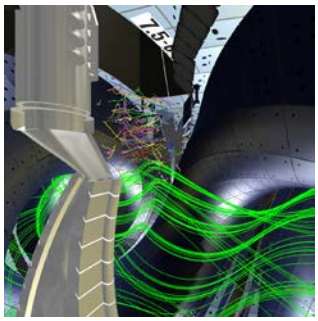

Fig.1. Integrated VR visualization of time-sequential data of dusts, equilibrium plasma simulation result and the inner surface of the LHD vacuum vessel. The dust trajectories are shown with the magnetic-field streamlines in green and red near the 7.5-U port.

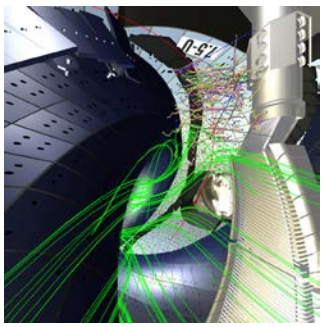

Fig.2. The same as Fig.1 but different view.

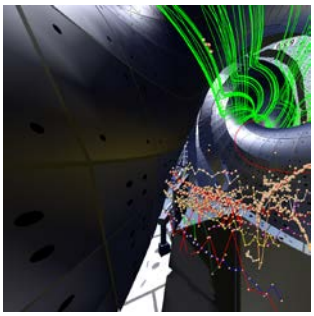

Fig.3. The same as Fig.1 but near the 7.5-L port.

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