§26. Observation of the Three-dimensional Trajectories of Dusts with Stereoscopic Fast Framing Cameras in LHD Plasmas

Shoji, M.

Recent ICRF heated long pulse discharges have been terminated with abrupt increase of carbon emission. Tangentially viewing fast framing cameras observed the release of a large amount of dusts from the divertor region. It suggests that the penetration of dusts into the main plasma caused the radiation collapse at the end of the discharges. For understanding the physical mechanisms of transport of dusts, stereoscopic fast framing cameras have been installed in an outer port (3-O) and an upper port (7.5-U).

Stereoscopic observations of some representative dust trajectories taken with the cameras installed in the outer and upper ports are shown in Figure 1 (a) and (b), respectively. These figures are superimposed images taken at some different times and plasma discharges in the case of an inward magnetic axis shift configuration (R_{ax}=3.60m). Dusts in the plasma are identified as small incandescent moving spots on the images. The arrows and small triangles in the figures indicate the direction of the movement of the dusts, and the positions at the intervals of the exposure time of the cameras. It clearly presents that the dusts move with acceleration and there are many varieties of dust trajectories.

The three-dimensional trajectories of dusts are reconstructed by analyzing the traces of the moving spots on the images observed from the two different positions using a pinhole camera model. It requires a camera matrix which is for mapping from three-dimensional coordinates of dusts to two-dimensional coordinates of the image sensor built in the fast framing cameras. In order to obtain the camera matrix, spatial calibration of the whole camera system was performed after experimental campaigns by reproducing the spatial configuration of the optics in a laboratory.

Figure 2 (a) is a view of reconstructed three-dimensional dust trajectories. Gray lines (dots) represent the dust positions observed at the intervals of the exposure time of the cameras. In this figure, the dust trajectories observed from the two ports are combined into one LHD toroidal section (0°<ϕ<36°). Small white dots represent the magnetic field lines in the peripheral plasma. It proves that the dusts locate in the peripheral plasma. Enlarged views of the observed dust trajectories from the outer and upper ports are presented in Figure 2 (b) and (c), respectively. The representative dust trajectories are indicated by white arrows, and the moving directions are expressed by small black arrows, showing that most of the dusts approximately move along the magnetic field lines with acceleration. Dust trajectories in the upper and lower divertor legs, each of which is shown as aggregates of gray lines (dots) in left-lower and right-upper area in Figure 2 (c), seem to be brushed away along the magnetic field lines in the upper and lower divertor legs.

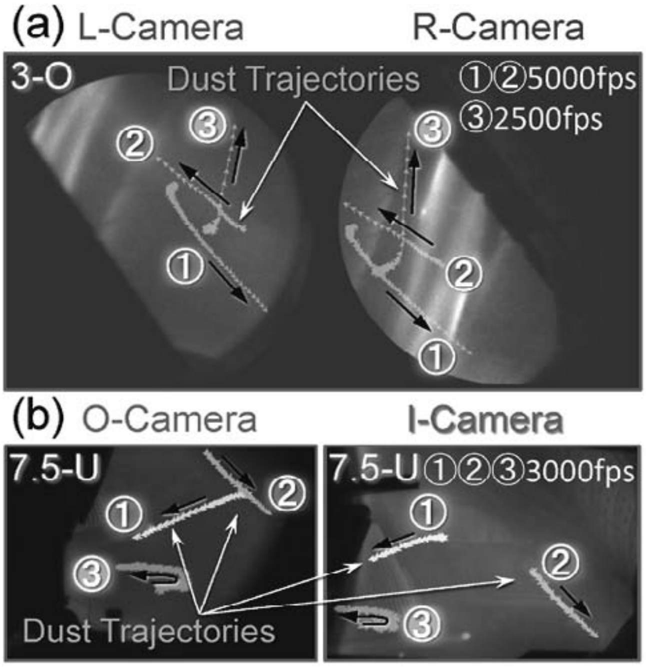

Fig. 1. Stereoscopic observations of representative dust trajectories from outer (a) and upper ports (b).

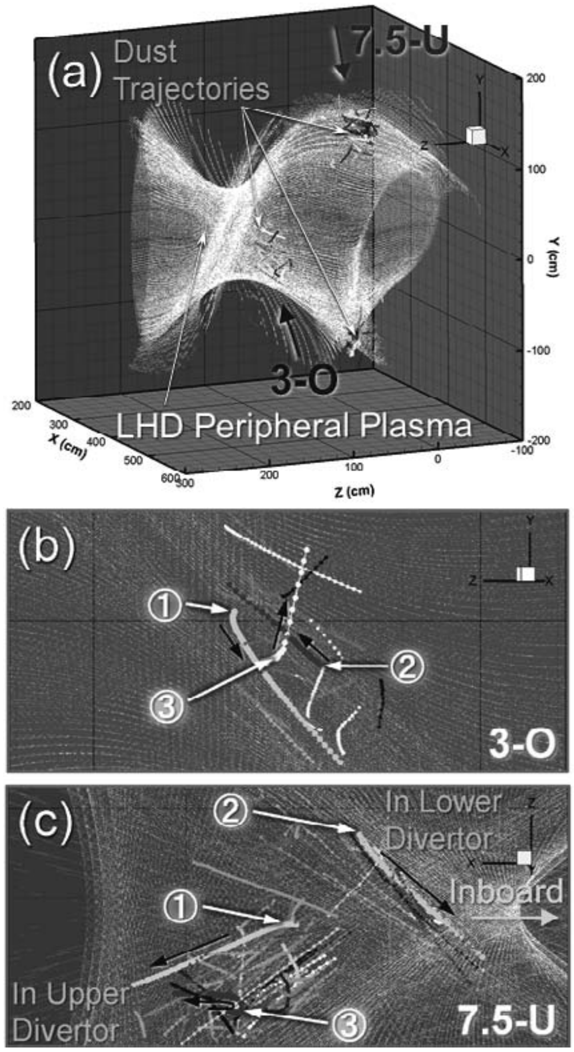

Fig. 2. Reconstructed three-dimensional dust trajectories (a). The enlarged view of the dust trajectories from outer (b) and upper ports (c).