# §21. Dust Transport Analysis in a Long Pulse Discharge in LHD

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Long pulse discharges assisted by ICRF with ECH in the Large Helical Device (LHD) were often terminated with release of large amounts of dusts from divertor regions in the previous (17th) experimental campaign in FY2013. Thus, investigations on the transport of dusts and the effect on the main plasmas become one of essential issues for extending the duration time of long pulse discharges.

The position of the source of the dust emission in a long pulse discharge in the previous campaign was identified by observation with a fast framing camera and a CCD camera for monitoring plasmas. The dust source was located on a dome structure in a closed divertor region near a lower port (4.5-U) in the inboard side of the torus. After the experimental campaign, the traces of the exfoliation of carbon-rich mixed material layers deposited in the closed divertor region were found on the site. It indicates that the origin of the dusts is the mixed material layers exfoliated from the divertor region.

The trajectories of the dusts in the long pulse discharge are investigated using a dust transport simulation code (DUSTT) which was modified for the analyses in fully three-dimensional geometries such as LHD plasma configurations.[1)] In the simulations, the three-dimensional profile of background plasma parameters (the ion/electron temperature and density and the plasma flow velocity, etc.) are from the calculations of a three-dimensional peripheral plasma code (EMC3-EIRENE) for a plasma heating power at the Last Closed Flux Surface ($P^{LCFS}$) of 1.0MW and a plasma density at the LCFS ($n_e^{LCFS}$) of $1.0\times10^{19}$m$^{-3}$, which are typical values in the long pulse discharge. It is assumed that the dusts consist of pure carbon and the shape of the dusts is spherical.

Figure 1(a) shows an aerial view of the three-dimensional model of a LHD plasma and the vacuum vessel for the simulation. The position of the dust source (shown as a small red circle) is set on the dome in the closed divertor region near the lower port. The initial velocity of the dusts is set to be 5m/s which is a typical dust velocity observed with stereoscopic fast framing cameras. The direction of the dusts was set to that toward the plasma center. An enlargement view of the tree-dimensional trajectories of the carbon dusts is presented in Figure 1(b) as thick lines, in which the radius of the dusts ($r_{dust}$) is changed from 1μm to 1mm. The position of the end points of the trajectories marked with crosses (X signs). The simulations show that small sized dusts ($r_{dust}$≤4μm) are swept off by the effect of the plasma flow (ion drag force) in a divertor leg close to the dust source. Medium sized dusts (4μm<$r_{dust}$≤100μm) reach to the ergodic layer and sublimate there by high heat load on the dusts in the peripheral plasma. The largest sized dust ($r_{dust}$=1mm) goes through the divertor leg and the ergodic layer, and penetrates into the main plasma, which can cause radiation collapse in the long pulse discharge.

1) Shoji, M. et al.: Plasma Fusion Res. **9** (2014) 3403132.

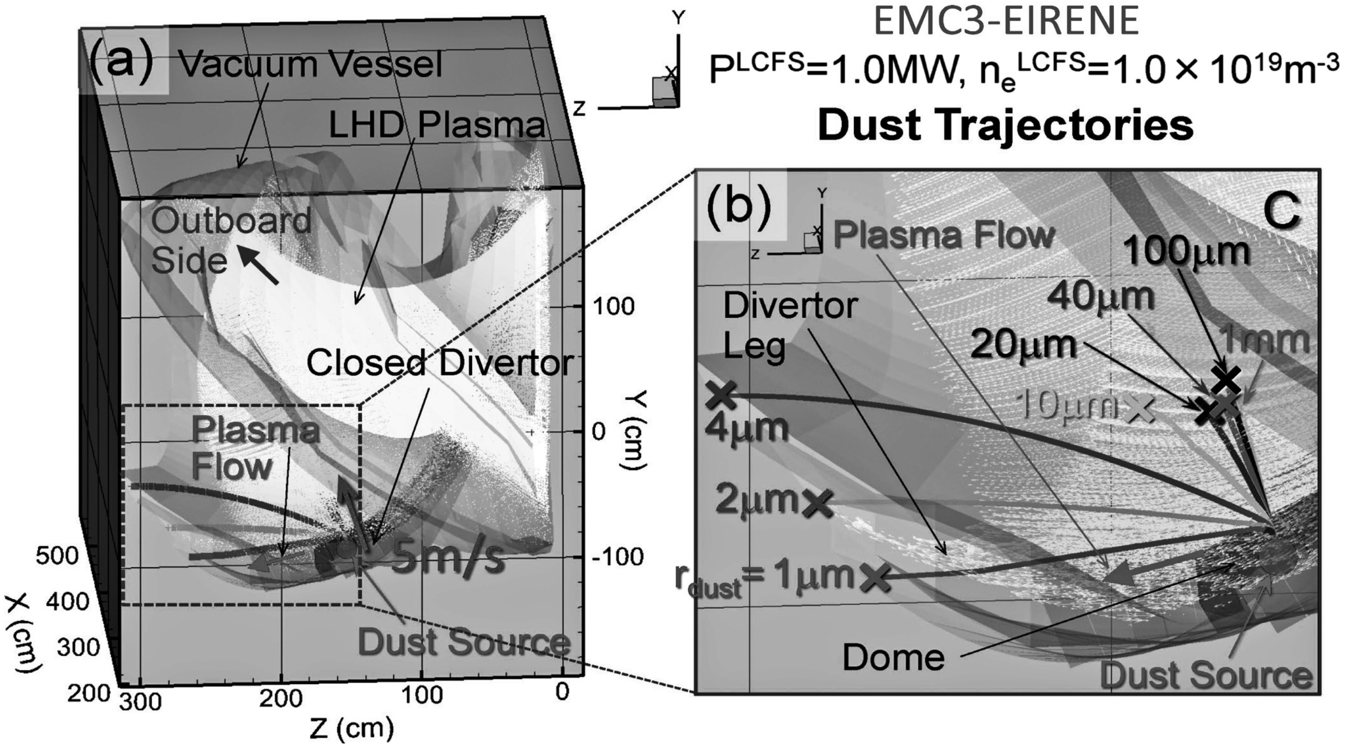


Fig. 1. An aerial view of the three-dimensional model of a LHD plasma and the vacuum vessel for dust transport simulation (a), and an enlargement view of the simulations of dust trajectories with various dust radii (b).