§2. Simulation of Impurity Transport due to Emission of Dusts in Long Pulse Discharges

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Termination of long pulse discharges due to the emission of the large amounts of dusts from two different positions was observed. One is carbon dusts released from a lower closed divertor region, and another one is iron dusts from the surface on a helical coil can in the inboard side of the torus. For investigating the influence of the dust emission on sustainment of the plasmas, simulation of impurity transport due to the dust emission was performed using a three dimensional peripheral plasma simulation code (EMC3-EIRENE) coupled with a dust transport code (DUSTT). Figure 1(a) illustrates a perspective view of a three-dimensional model of the LHD vacuum vessel and the closed divertor components for the simulation. In this model, a number of iron dusts are emitted from a surface of a helical coil can, and carbon dusts are released from a lower divertor region to the plasma center as shown in Figure 1(b) and (c), respectively. The figures clearly indicate that the most of the dust trajectories from the lower divertor region are bent at divertor legs, which is mainly caused by the effect of the plasma flow. It means that the divertor leg is effective to prevent the dusts from reaching the main plasma. On the other hand, it also shows that the dusts released from the helical coil can directly reach the main plasma.

The calculated radiation power and the divertor electron temperature as a function of the current of the dust emission for a typical heating power and plasma parameters in long pulse discharges (P^{LCFS}=1MW, $n_e^{LCFS}=1\times10^{19}$m^{-3}) for iron and carbon dust emission are shown in Figure 2. The divertor electron temperature decreases and the radiation power increases with the dust current. When the dust current exceeds one providing a divertor electron temperature less than around 8~7eV, no converged solution was obtained, meaning that the electron temperature becomes too low to prevent the dusts from penetrating the main plasma by evaporating/sublimating the dusts. The electron temperature becomes low at a dust current of ~9A for iron dust emission, indicating that the sustainment of long pulse discharges is easily disturbed by the emission of iron dusts from the helical coil can compared to that for the emission of carbon dusts from the divertor region.

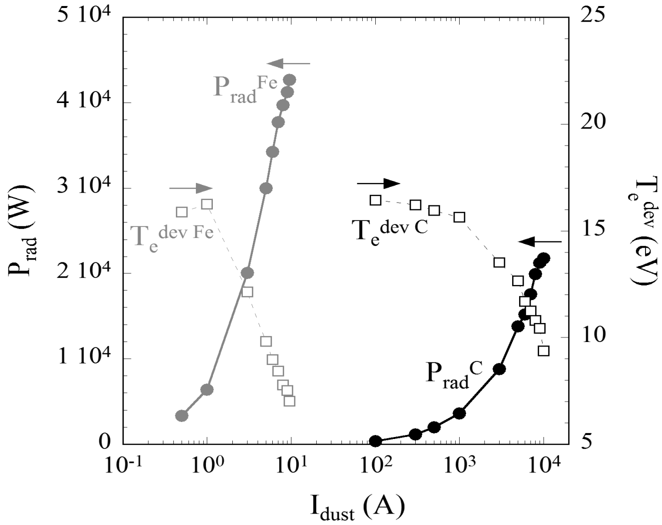

Fig. 2. Calculated radiation power and divertor electron temperature for iron and carbon dust emission as a function of the dust current.

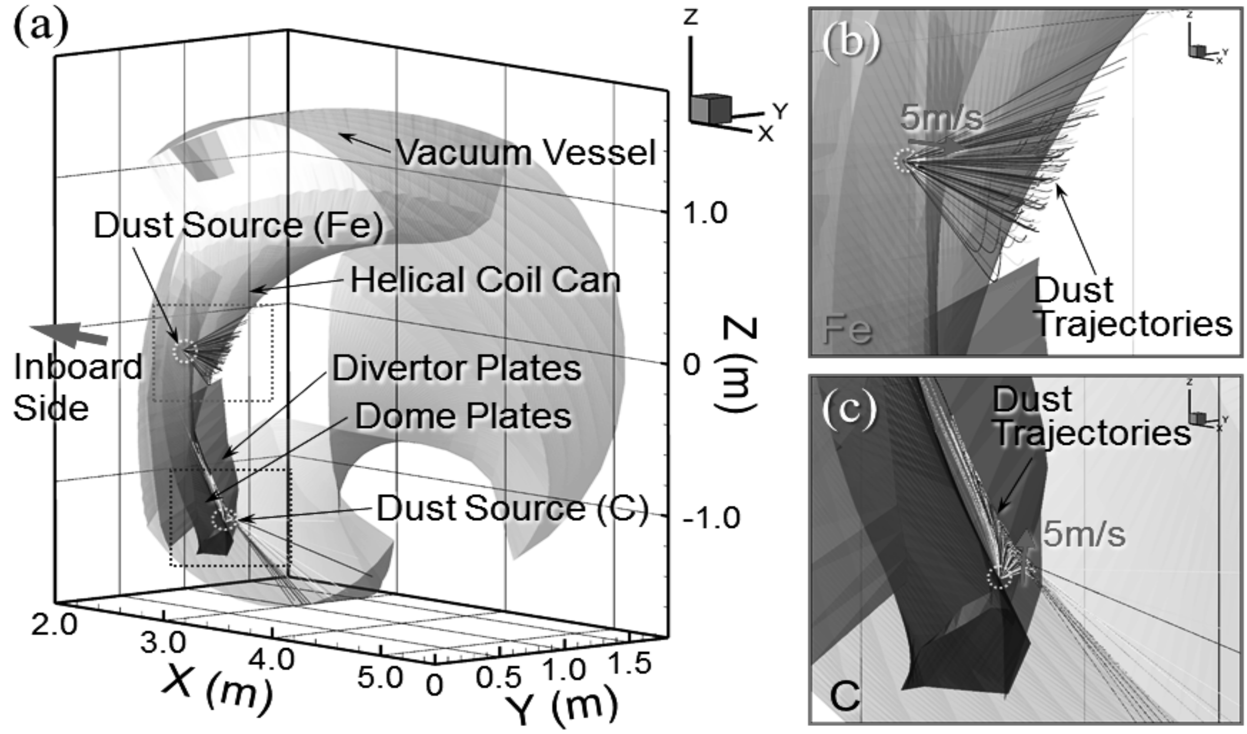

Fig. 1. (a) A perspective view of the LHD vacuum vessel and the closed divertor components for the simulation. The trajectories of iron dusts released from a helical coil can (b) and carbon dusts from a lower divertor region (c).