§25. Simulation Analysis of Dust Transport in LHD Peripheral Plasmas

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Recent ICRF heated long pulse discharges have been terminated with abrupt increase of carbon emission in the plasmas. Tangentially viewing fast framing cameras observed the release of a large amount of dusts from a divertor region at the end of the long pulse discharges. It suggests that the penetration of dusts into the main plasma terminated the plasmas by radiation collapse.

For analyzing the transport of dusts in plasmas and the effect of dusts on the main plasma performances, a dust transport simulation code (DUSTT) has been introduced. This code has been originally developed for analysis in axisymmetric geometry like Tokamak plasmas. For applying the code to non-axisymmetric geometry such as LHD plasmas, a dust tracking sub-program in the DUSTT code was implemented in a three-dimensional neutral particle transport code (EIRENE). It enables to simulate dust transport in fully three-dimensional configurations.

Figure 1 is a bird's-eye view of the thee-dimensional geometry of the LHD for R_{ax}=3.60m with the calculated plasma flow velocity distribution in the peripheral plasma including an ergodic layer and divertor legs. Profiles of background plasma parameters (ion/electron density and temperature, parallel plasma flow velocities, etc.) which are necessary for the dust transport simulation is supplied from a three-dimensional edge plasma fluid code (EMC3-EIRENE) in the case where the heating power and the plasma density at the Last Closed Flux Surface (LCFS) are 2MW and 2×10^{19}m^{-3}, respectively.

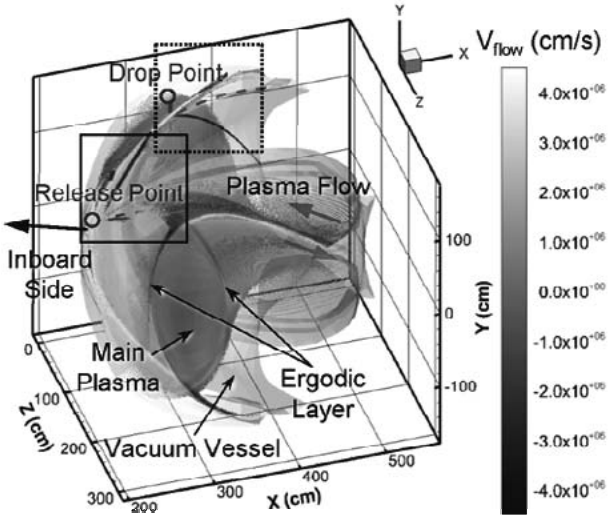

Fig. 1. Bird's-eye view of the LHD geometry with a calculated plasma flow velocity distribution.

In the simulation, the following two probable situations in LHD are assumed:

1. Release of spherical iron dusts from a divertor plate installed in the inboard side of the torus,
2. Free drop of spherical carbon dusts from a vertically installed divertor plate near an edge of an upper port.

Figure 2 (a) and (b) give the enlarged views of the calculated dust trajectories for the first and second situations for various sized dusts, respectively. The positions of the area of these figures correspond to the squares surrounded by the solid and broken lines in Figure 1. The simulations indicate that while relatively small sized dusts (<10μm) are brushed away by the effect of the plasma flow in the divertor legs, relatively large sized dusts (>40μm) penetrate the divertor legs, and reach to the ergodic layer to be evaporated/sublimated by the high heat load by the high plasma temperature (>100eV) in the ergodic layer. The simulation clearly indicates that the peripheral plasma have a function for shielding the main plasma from penetration of dusts released from divertor plates.

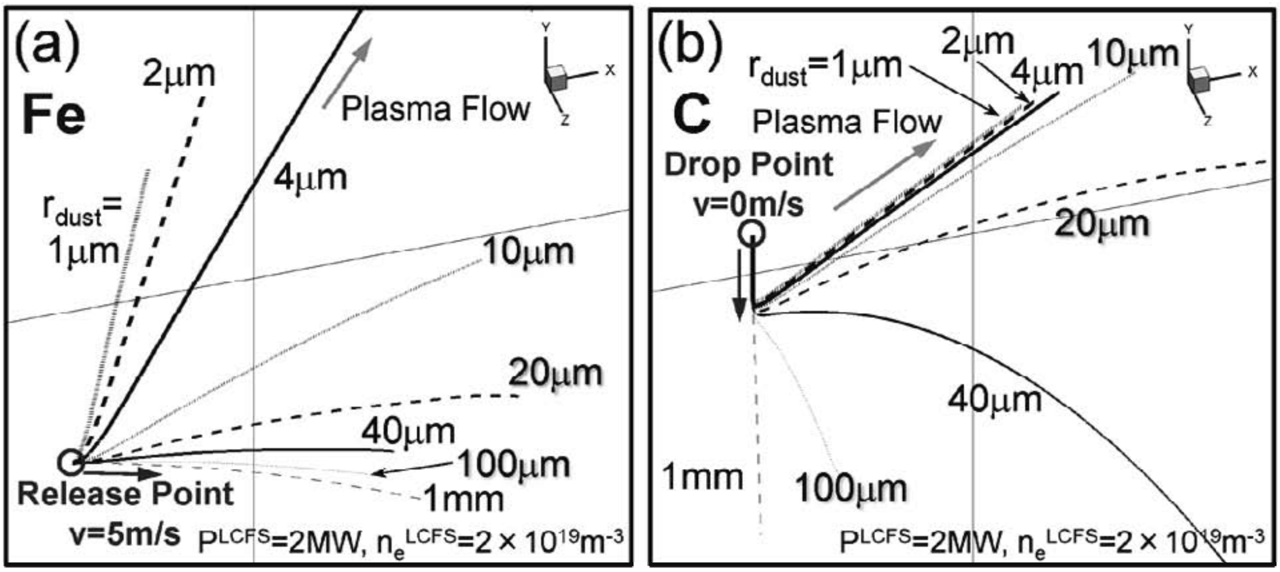

Fig. 2. Enlarged views of the calculated trajectories of spherical iron dusts in the first situation (a), and those of carbon dusts in the second situation (b) for various sized dusts.