§30. Study of Dust Transport in LHD Plasmas

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Dust will be a serious problem in fusion devices because dust formation in next-step devices is expected to be enhanced due to a long pulse operation. Dust accumulation inside the vacuum vessel contributes to huge tritium inventory. In order to understand accumulation process of dust particles, we need to study dust transport. In the previous experiments of the LHD, therefore, we injected carbon dust particles by using material probe system into a plasma and the motion of dust particles was measured with a high-speed camera. In this study, we have developed 3 D dust transport code for aim at analyzing dust motion observed in LHD.

In the simulation code, we take into account gravitational force, electrostatic force, Lorentz force, ion-drag force and friction force between a dust particle and neutral gases as forces acting on a dust particle in a plasma. In order to evaluate the validity of the developed simulation code, we compared with the calculated results and experimental ones of the dust transport obtained in the NAGDIS-T. We used spherical carbon dust particles whose radius is about 8 micron. We dropped dust particles from the top of the vacuum vessel into a deuterium plasma. We set containers on the bottom in toroidal and radial directions to collect dust particles transported in a deuterium plasma.

Figure 1 shows coordinates used in the simulation. The direction of major radius and hight are x- and y-axes,respectively and the troidal direction is z-axis. $x = 0$ cm and $y = 0$ cm correspond to surface of inner wall and that of top wall. The dust feeder is located at a position of (9, 0, 0). Troidal magnetic field strength is 4.0×10^{-2}T, and vertical one is 1.8×10^{-3}T, and neutral temperature is 400K. Reflection coefficient of a carbon dust particle on the surface of stainless steal wall is assumed to be 0.78, estimated based on a shore hardness of a sphere carbon particle. Plasma parameters in the simulation, such as electron density, temperature and plasma flow, were obtained in the experiment. The experimental result indicates that plasma rotates poloidally around a plasma column due to $E \times B$ drift, where the plasma center is $x = 10$ cm and $y = -7$ cm.

Figure 2 shows calculated dust trajectories . In Fig. 2(a) (the dust radius is 0.5 micron), in the upper region of the vacuum vessel from -7 to 0 cm, a dust particle, introduced from the top, receive strong outward ion drag force due to ExB plasma flow, so a dust particles is transported outward, and is reflected at the outer wall. The reflected dust particle moves inward, but the direction of the dust motion is changed by the ion drag force and the dust particle hit the outer wall again. Finally, the dust particle reaches on the bottom. On the other hand,
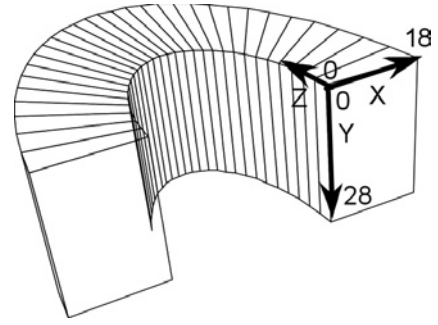

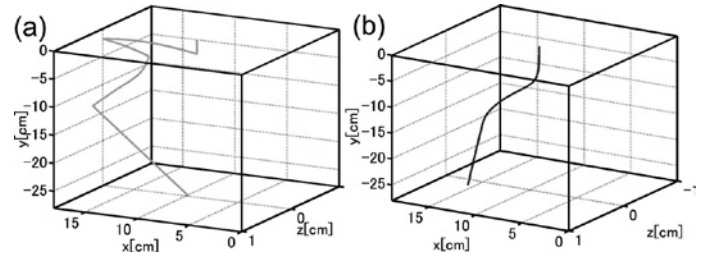Fig. 1: Coordinate in the simulation code.

Fig. 2: Calculated dust trajectories of a dust particles with a radius of (a): 0.5 micron and (b) 6.0 micron.

a large dust particle of 6 micron can not reach the outer wall, and fall down on the bottom of the vacuum vessel directly. Figure 3 shows radial distributions of mass of
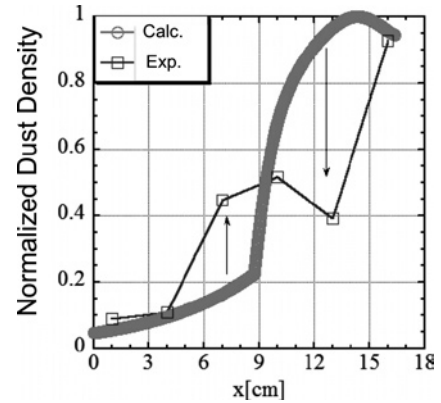

Fig. 3: Comparison between radial distributions of mass of dust particles in the experiment and the simulation.

dust particles collected by containers. The simulation result is in a good agreement with that in the experiment, except for data points around $x = 7$ cm and $x = 13$ cm. The discrepancy is found to be caused by an influence of the viewing ports located in the bottom of the vacuum vessel.

We will analyze the dust transport date in the LHD by using the developed 3D dust transport code in near future.