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LHDにおけるプラズマ周辺部のダストの三次元輸送シミュレーションとステレオ視高速カメラによるダストの軌道計測

Three-dimensional simulation of dust transport in the plasma periphery and stereoscopic measurement of the trajectory of dusts in the Large Helical Device

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The transport of dust particles in magnetic plasma confinement devices has been attracting attention because it affects plasma operation and performances. For example, the termination of some ICRF heated long pulse discharges in the Large Helical Device (LHD) was caused by so called ‘spark’ events on the vacuum vessel, resulting in accidental injection of a large amount of iron included in dusts into the plasma.

Toroidally non-axisymmetric magnetic field components in the LHD form ergodized magnetic field line structures in the plasma periphery: divertor legs and an ergodic layer. The LHD peripheral plasma, which surrounds the main plasma confinement region inside of the last closed flux surface (LCFS), has a function of shielding against invasion of impurity ions into the plasma. The peripheral plasma possibly has also the shielding effect against dusts which originate from exfoliated co-deposition layers accumulated on the surface on divertor plates and the vacuum vessel.

In order to investigate the shielding effect, a dust transport simulation code (DUSTT) was applied to the LHD geometry. This code has been originally developed to dust transport analysis in toroidally axisymmetric configurations such as Tokamaks, which strongly couples with a two-dimensional edge-plasma transport code (UEDGE). For extending the DUSTT to the non-axisymmetric geometry such as LHD, subprograms for tracking the trajectory of dusts in the DUSTT were modularized and implemented in a program module for tracking ionized test particles in a fully three-dimensional neutral particle transport simulation code (EIRENE). The three-dimensional grid model for the EIRENE provides a geometrical condition to track the trajectory of dusts in the LHD vacuum vessel. A fine grid model for a three-dimensional plasma edge transport code (EMC3) including plasma parameter profiles was used for the detailed dust trajectory analysis.

Figure 1 shows a three-dimensional model of the LHD geometry for dust trajectory analysis. Small colored allows indicates the magnitude and the direction of the plasma flow in the periphery. In this figure, the dependence of dust’s trajectory on the dust radius (Carbon), which are released from a divertor plate installed in the upper inboard side of the torus and dropped from an upper part in the vacuum vessel, are shown in an LHD standard magnetic configuration (R_{ax}=3.60m).

The shielding effect of the peripheral plasma (a ergodic layer and divertor legs) against the dust invasion into the LHD main plasma will be numerically investigated by sophisticated three-dimensional dust transport simulation using the DUSTT implemented in the EIRENE coupling with the EMC3.

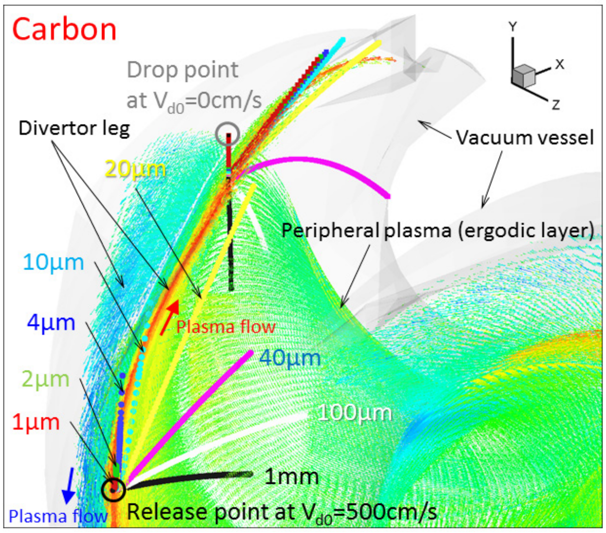

Fig.1 Simulations of the three-dimensional trajectory of dusts (Carbon) in the LHD geometry.