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Fast-framing camera observations of the trajectory and the ablation position of dust particles injected by the multi-species impurity powder dropper in the Large Helical Device

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Impurity powder injection has been expected to be an attractive optional technique for impurity seeding, wall conditioning, and dust transport studies in magnetic plasma confinement devices [1]. A multi-species impurity powder dropper (IPD) [2] was installed at an upper port in the Large Helical Device (LHD). The control of the trajectory of the dust particles injected by the IPD in the peripheral plasma is a critical issue for realizing high-performance plasma discharges [3]. The ablation positions of dust particles were routinely observed with a fast-framing camera and a CCD camera for monitoring the plasma discharges from upper ports.

Figure 1 shows snapshots of the ablation images of injected boron dust particles (150 μm in diameter) in the LHD peripheral plasma observed with the fast-framing camera installed at the position close to the IPD. They were taken in an initial phase of the start of the dust particle injection for three different plasma densities in a typical magnetic configuration (the radial position of the magnetic axis R_{ax}=3.60 m). The dust particles dropped from the IPD pass through an upper divertor leg before reaching the peripheral plasma (the ergodic layer). A few moving small luminescent spots were detected by the camera, showing the ablation of the dust particles caused by the interactions between the dust and the peripheral plasma. The images clearly indicate the change in the ablation positions toward the outboard side of the torus for higher plasma densities.

Analyses using a three-dimensional edge plasma simulation code (EMC3-EIRENE) [4] coupled with a dust particle transport simulation code (DUSTT) [5] revealed that the trajectory of impurity dust particles is deflected toward the outboard side by the effect of the ion drag force due to the plasma flow in an upper divertor leg [6]. The simulation also predicted that the ablation positions of the dust particles further move toward the outboard side with the increase in the plasma density by the larger ion drag force on the dust particles in higher plasma densities. The simulations are consistent with the observations.

At this conference, the results of the more sophisticated analyses of the trajectories and ablation positions of the dust particles are presented by including the effect of the impurity ion flow caused by the impurity powder injection into the simulation code.

References

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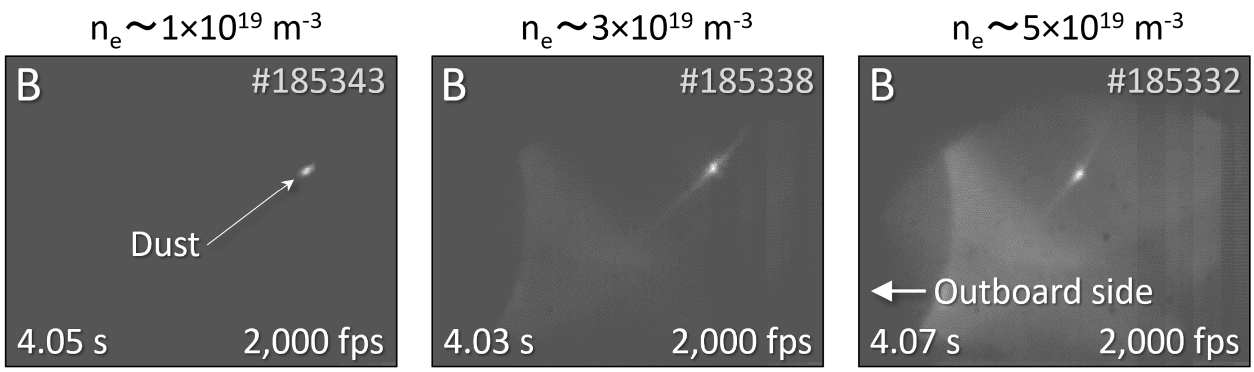

Figure 1: The snapshot of the ablation images of boron dust particles injected by the IPD observed with a fast-framing camera installed in an upper port in an initial phase of the start of the dust particle injection for three different plasma densities in a typical magnetic configuration (R_{ax}=3.60 m).