§24. Characterization of Dust Dynamics in LHD

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Dynamic behavior of dust particles has been investigated in the Large Helical Device (LHD). A high-speed infrared camera viewing the inboard side from an outer port provides information about the movement of dust particles as well as their temperature. Characterization of heated dust particles during plasma discharges is reported for the first time. Imaging measurements in the infrared range have an advantage over visible light imaging because they can detect invisible dust particles which do not heavily interact with the main plasma. This feature is essential to clarify the origin of the dust.

The directions of the moving dust particles are not uniform as shown in Fig.1. These heated dust particles are only observed during main discharges and have not been observed in glow discharges. This image is taken in the phase 0.2 s after the neutral beam heating is turned off. The heating source of dust particles is considered to be heat fluxes from the plasma.

A study based on collection of dust after the vacuum venting indicates that there are two major types of dust in LHD. One is spherically shaped carbon and the others are irregularly shaped metal compounds including iron, nickel, chromium and molybdenum. The size of a carbon dust particle is less than 1 micron and the size of a metal dust particle is greater than 1 micron. The temperature of heated dust is evaluated from the intensity of the infrared measurement. Since the constituents of the observed dust have not been identified yet, the dust particles are assumed to be made of carbon or iron from the above mentioned study. The size ratio between the size of the dust and the observing area per camera pixel also affects the estimation of the temperature. The observing area by one pixel is about 1-20 mm^2 and this area is significantly larger then the dust diameter (typically 1 micron). Therefore the temperature of the dust is assumed to be higher than this estimation.

The velocity of dusts is evaluated from the distance moved and the frame rate. The distance moved is depends on the radial position in the field of view of the infrared camera. However, this position with respect to the plasma can be determined by using the reflected image of the heated dust particle on the first wall in this experiment. In Fig.1, the position of the dust particle D1 is identified as behind the plasma and the detailed location is measured using the 3-D CAD by this method.

Intensity and two kinds of velocity of the dust particle D1 by infrared camera are shown in Fig.2. Projected velocities on the viewing plane, V_0, and a tracing velocity, V_t, using the reflected image method with the three-dimensional position of the dust at 1.208 s are determined for D1. The parameters of the main plasma do not change significantly during this phase. This dust mainly moves in the vertical direction and this velocity is increasing from 5 to 20 m/s as shown in Fig.2. Velocities of other heated dust particles observed during this discharge are slower or faster than that of D1. Characteristics of moving dust particles depend on their velocity. High-speed dust mainly moves in a straight line and slow dust does not maintain a constant direction.

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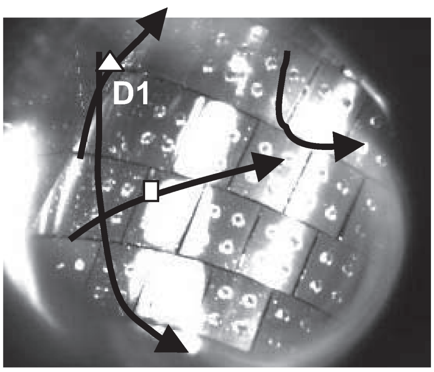

Fig.1 Movement of heated dust particles observed by infrared camera and moving directions as shown by allows. A dust particle of D1 is analyzed. Dashed line is a point of reflected images by D1.

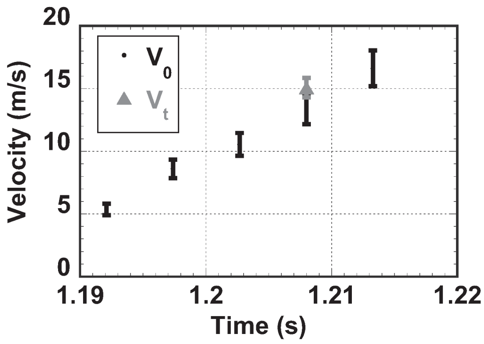

Fig. 2 Time evolutions of two kinds of velocity of the dust D1 in Fig.1. V_0 is projected velocity and V_t is tracing velocity using the reflected image method at 1.208 s.