§15. Redeposition of a Dust Particle in SOL/Divertor Plasma of HL-2A Tokamak

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Redeposition of a iron dust particle is studied in the SOL (Scrape-Off Layer)/divertor plasma of the HL-2A tokamak in Southwestern Institute of Physics, China, with a single-null configuration [1]. The background plasma parameters in the SOL/divertor region of the HL-2A tokamak, necessary for the dynamics study of the dust particle, is given by the B2-EIRENE code for the 500 kW heat flow from the core plasma to the SOL/divertor region with the single null configuration [2]. The stagnation point of the parallel ion flow is located at the top of the SOL region. The dust particles produced on the first wall, which is made of SS, move to the divertor plate along the parallel direction due to the strong plasma flow.

The dependence of the final speed at the divertor and the passing time on the dust radius is shown in Fig.1. The larger the dust particle radius is, the lower its acceleration and the longer time to the divertor, see in Fig. 2, where the parallel dust speed at the divertor plate and the time period from the stagnation point to the divertor plate along the high-field side are shown as a function of the dust radius. The final speed at the low-field side is quite similar to the cases of the high-field side. The smaller dust particle with the dust radius of 1 nm is accelerated up to around 5 km/s in 5 ms. On the other hand the final speed of the larger dust with the 1 mm radius only reaches around 1 m/s in 10 s.

From the comparison of the kinetic energy of the dust particle vertical to the wall with the electrostatic potential energy of the sheaths, including the electrostatic Debye sheath and the magnetic presheath, the redeposition condition of the dust particle on the wall is roughly estimated. The dust particle with higher speed can overcome the sheath potential and redeposit to the diverter plate. The poloidal direction at the divertor plate is almost normal in the HL-2A divertor configuration. Therefore the kinetic energy of the dust particle to the normal direction is almost the poloidal dust energy:

$$\varepsilon_{d,\,perp} \simeq \frac{m_d}{2} v_{d,pol}^2 , \qquad (1)$$

where $v_{d,pol}$ is the poloidal dust speed. The potential energy of the dust to the divertor plate for the case of floating wall:

$$U_d = Z_d e\left|\phi_{fs}\right| = \frac{Z_d T_e}{2} \ln[(2\pi \frac{m_e}{m_i})(1+\frac{T_i}{T_e})] , \qquad (2)$$

where ϕ_{fs} is the floating wall potential drop. The ratio of $\varepsilon_{d,\,perp}$ to U_d is shown in Fig.2 as a function of the dust radius, where in the case of the ratio less than unity, the dust particle cannot overcome the sheath potential energy and then is reflected. The dust particles traveling along the high-field side have the large ratios than along the low-field side. In the SOL/Divertor plasma of the HL-2A tokamak, even at the low-field side dust particles are almost deposited on the divertor plate because of the very low electron temperature (few eV), compared to the high kinetic energy of the dust. The condition of the reflection and the redeposition of the dust particle on the divertor plates are investigated more carefully, where the effects of the sheath potential and the wall need be included.

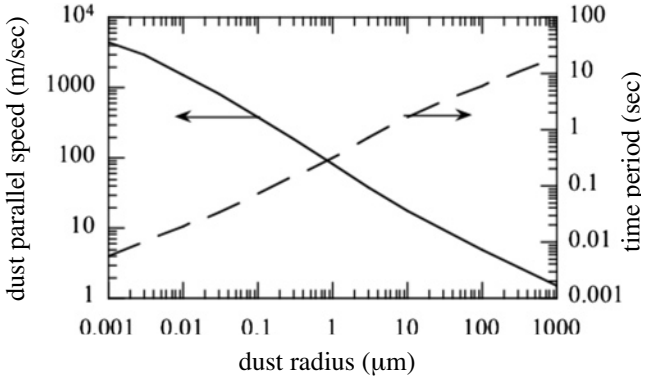

Fig.1 The dependence of the parallel dust speed at the divertor and the time period on the dust radius at the high-field side.

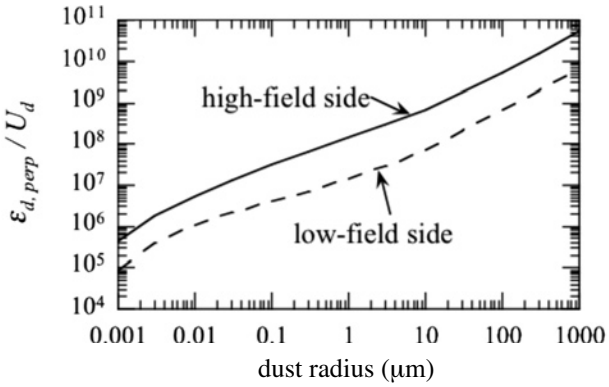

Fig. 2 The ratio of $\varepsilon_{d,\,perp}$ to U_d as a function of the dust radius for the cases of the high and the low field sides.

1) Liu, Y., Ding, X.T., Yang, Q.W., et al., Nucl. Fusion **45**, S239 (2005).
2) Pan, Y.D. and Schneider, R., J. Nucl. Mater. **363-365**, 407 (2007).