§12. Release of Dust Particle from Plasma-Facing Wall —Effects of Truncation of Electron Distribution—

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The effects of truncated electron velocity distribution on the release conditions of the spherical dust particle are discussed in the case of the gravitational force directing toward or from the conducting wall.

When the gravity is pushing the dust toward the wall, there exists the threshold wall potential to be released of dust from plasma-facing wall. In Fig. 1, the critical dust radii normalized by the Debye length at the sheath entrance λ_{Dese} with truncation effect are shown as a function of the wall potential drop for the case $Z_i = 1$, $\ln\Lambda = 3.0$, and, where the threshold wall potential is 1.40. The parameter δ_{ga} in Fig.1 indicates the effect of the gravitational force,

$$\delta_{ga} \equiv 0.038 \frac{\rho_d(g/cc)\cos\alpha}{n_{se,19}\sqrt{n_{se,19}\,T_e(eV)}}, \qquad (1)$$

where $n_{se,19}$ is the plasma density at the sheath edge in the unit of 10^{19} m^{-3}. Here $\delta_{ga} = 0$ corresponds to the dust particle on the vertical wall. The dusts with the radius smaller than the critical one will be released. The larger the gravitational effect becomes, the smaller the released region becomes. In the case of the carbon dust on the horizontal wall in a plasma with high density 10^{18} m^{-3} and $T_e = 10$ eV, which corresponds to a divertor plasma in fusion devices, the gravitational parameter is as low as 0.78. On the other hand, the low density plasma 10^{16} m^{-3} with T_e = 3 eV increases the gravitational parameter up to around 1400, where almost dusts are pinned to the wall except for quite small dusts. In the case of electron distribution without truncation, the threshold wall potential moves to 1.66, but the critical radii at the deep wall potential are almost the same.

The gravitational force directing from the wall easily releases the dust particle. The critical radii are shown in Fig.2 for the cases of δ_{ga} = -5 (a), -6.52 (b), and -7 (c), where the solid and dashed lines indicate the case with and without truncation effect, respectively. At the small magnitude of δ_{ga}, Fig.2 (a), the released regions of the dust radius are separated into two regions, where the released region at the shallower wall potential than threshold does not appear in the case of the positive gravitational parameter. On the other hand for the larger magnitude of δ_{ga}, Fig.2 (c), these two released regions are overlapped. The gravitational parameter δ_{ga} = -6.52 , Fig.2 (b) is the marginal one for the case with truncation, where the two released regions are merged. At the released dust region in the shallower wall potential, where the repulsive electrostatic force is not so strong, the gravitational force makes the dust particle release. One can see the truncation effect is significant at the shallower potential drop. A dominant force divides the region in Fig.2 into four parts. In the shallower potential and the larger dust region, the gravitational force is dominant. The strong electrostatic force releases the dust from the wall in the deeper potential drop and the smaller dust particle. In the pinned dust region with the deeper wall potential and the larger dust particle, the Coulomb scattering force pushes the dust toward the wall. On the other hand in the shallower potential with the smaller dust, the ion drag force due to absorption of ions by the dust is dominant compared to the other forces.

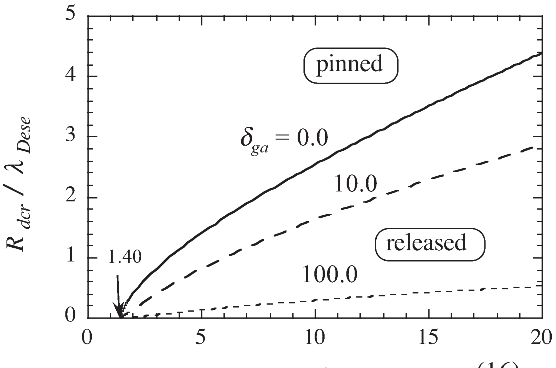

Fig.1 Critical dust radii with truncation effect as a function of normalized wall potential drop for the cases of gravitational parameter δ_{ga} = 0.0, 10.0, and 100.0 and Z_i = 1, $\ln\Lambda$ = 3.0.

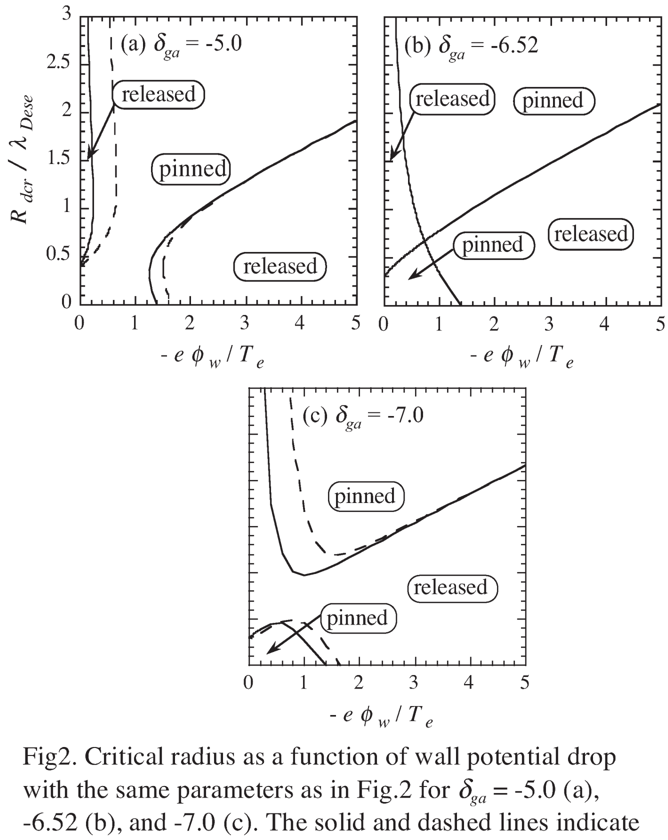

Fig2. Critical radius as a function of wall potential drop with the same parameters as in Fig.2 for δ_{ga} = -5.0 (a), -6.52 (b), and -7.0 (c). The solid and dashed lines indicate the case with and without truncation effect, respectively.