§11. Release Condition of Dust from Plasma-facing Wall and Effects of Surface Roughness in Oblique Magnetic Field

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The release condition of the dust particle from the plasma-facing wall is studied. In Fig.1, the critical radius for the release of the dust particle from the vertical flat wall is shown, where the electric field at the wall is solved by the Poisson equation including the ion polarization drifts. The larger dust particle than the critical one is pinned to the wall by the ion drag forces. In the middle region of the oblique angle ($11° \le \beta \le 74°$) for the weaker magnetic field or the higher ion density ($\delta_B = 5.0\times 10^{-3}$, solid line) there is no dust release region, because the ion drag force due to the ion absorption becomes larger than the repelling electrostatic force. Here *b* is the angle of oblique magnetic field from the wall normal and δ_B (= $\varepsilon_0 Z_i B^2 / (m_i n_{e0})$ characterizes of the effect of the magnetic field. In the case of the stronger magnetic field or the lower plasma density ($\delta_B = 5.0\times 10^{-2}$, dashed line), there exists the critical radius. The oblique magnetic field of 45° for the floating case increases the critical radius from 0.77 λ_{De0} to 0.97 λ_{De0}. The more acute magnetic field enlarges the released dust radius, because at the right angle (β = 90°) all pushing forces are vanishing in our model. For example the angle of 80° enlarges the released radius to 3.5 λ_{De0}.

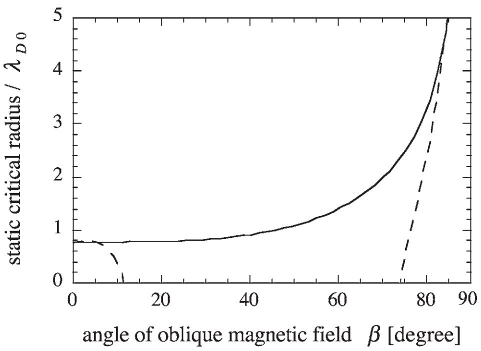

Fig. 1 The critical radius for the release of the dust particle normalized by the electron Debye length defined at the entrance of the MP as a function of the angle of oblique magnetic field.

In order to investigate effect of the surface roughness on dust release conditions it is modeled as a sinusoidal form with an amplitude a_s and a wavelength λ_s, which are assumed to be much larger than the dust radius. The angle β between the oblique magnetic field and the surface normal changes as a function of position at the wall and depends on the amplitude a_s and the wavelength λ_s:

a) $2\pi a_s / \lambda_s \le 1$ or $0 \le \theta_{sm} \le \pi/4$

$$\frac{\pi}{2}-(\theta_B+\theta_{sm}) \le \beta \le \frac{\pi}{2} \quad : \quad 0 \le \theta_B \le \theta_{sm}$$

$$\frac{\pi}{2}-(\theta_B+\theta_{sm}) \le \beta \le \frac{\pi}{2}-(\theta_B-\theta_{sm})$$

$$: \ \theta_{sm} < \theta_B \le \frac{\pi}{2}-\theta_{sm} \qquad (1)$$

$$0 \le \beta \le \frac{\pi}{2}-(\theta_B-\theta_{sm})$$

$$: \ \frac{\pi}{2}-\theta_{sm} < \theta_B \le \frac{\pi}{2}$$

b) $2\pi a_s / \lambda_s > 1$ or $\pi/4 < \theta_{sm} \le \pi/2$

$$\frac{\pi}{2}-(\theta_B+\theta_{sm}) \le \beta \le \frac{\pi}{2}$$

$$: \ 0 \le \theta_B \le \frac{\pi}{2}-\theta_{sm}$$

$$0 \le \beta \le \frac{\pi}{2}$$

$$: \ \frac{\pi}{2}-\theta_{sm} < \theta_B \le \theta_{sm} \qquad (2)$$

$$0 \le \beta \le \frac{\pi}{2}-(\theta_B-\theta_{sm})$$

$$: \ \theta_{sm} < \theta_B \le \frac{\pi}{2}$$

where θ_B is the angle between the oblique magnetic field and the vertical plane, and θ_{sm} (= $\tan^{-1} 2\pi a_s / \lambda_s$) is the maximum angle between the wavy surface and the vertical plane. Along the wavy surface the angle β widely spreads. For example, at the acute angle of oblique magnetic field θ_B (= 5°), the angle β changes from the minimum angle β_m to the right angle (β = 90°). The value of β_m changes from 21.6°, 40.0° and 58.4° for the case a_s / λ_s = 2.0, 1.0, 0.5, respectively. The high amplitude of the roughness leads to large variation of the angle β. On the other hand, at the obtuse angle of oblique magnetic field θ_B (= 85°), the angle β changes from 0° to the maximum angles, which are 68.4°, 50.0° and 31.6° for the case of case a_s / λ_s = 2.0, 1.0, 0.5, respectively. In this case when the wavelength of the surface roughness becomes longer, the angle β spreads widely. The large variation of the angle β along the surface can strongly affect the critical dust radius, when magnetic field is strong. In order to analyze the release condition of the dust on the rough surface more precisely, the effect of the gravity should be taken in to account.