§17. Electron Absorption Cross-sections to Spherical Probe in Weak Magnetic Field

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For the weak magnetic field, i.e. small μ_e, the closest radius r_{min}, which is corresponding to the probe radius, is approximated exponential dependence to the strength of magnetic field or μ_e,

$$\bar{r}_{\min}(\alpha_e,\mu_e,\zeta_{sc}) = 1+[\bar{r}_{\min 0}(\alpha_e,\zeta_{sc})-1]\exp[-\eta_e(\alpha_e,\zeta_{sc})\mu_e] \quad (1)$$

where the distances, velocity and time are normalized by the impact parameter b_{in}, the initial speed $\upsilon_{j,in}$ and $b_{in}/\upsilon_{j,in}$, respectively. In the case of the strong magnetic field, the closest radius $r_{\min}$ approaches the impact parameter $b_{\rm in}$ due to the straight motion along the magnetic line of force. Here $\zeta_{sc}(\equiv \delta_{sc}/\bar{\lambda}_D)$ is the parameter of the effect of the plasma shielding and η_e is the parameter, which depends on α_e and ζ_{sc}. The quantity $\bar{r}_{\min 0}$ is the closest radius in the absence of magnetic field, which is obtained from the OML theory:

$$\bar{r}_{\min 0}^2 - \alpha_e \bar{r}_{\min 0}\exp(-\zeta_{sc}\bar{r}_{\min 0}) - 1 = 0 . \quad (2)$$

In this study the parameter η_e is determined by the relation of $\mu_e = 1.0$:

$$\eta_e(\alpha_e,\zeta_{sc}) = \ln\{[\bar{r}_{\min 0}(\alpha_e,\zeta_{sc})-1]/[\bar{r}_{\min}(\alpha_e,\mu_e=1,\zeta_{sc})-1]\} \quad (3)$$

In the case of $\alpha_e = 1.0$, which corresponds to the negative applied voltages, and $\zeta_{sc} = 0$, the η_e becomes 0.602. The η_es for the cases of the weak shielding, $\zeta_{sc} = 0.3$, and strong one, $\zeta_{sc} = 1.0$, the parameter η_es decrease to 0.421 and 0.222, respectively. On the other hand, in the case of positeve V_p ($\alpha_e = -1.0 < 0$), the η_es for the case of $\zeta_{sc} = 0$, 0.3 and 1.0 become 0.751, 0.553 and 0.339, respectively. The parameter η_e is approximated by the polynomial of degree three as a function of α_e:

$$\eta_e(\alpha_e,\zeta_{sc}) = c_0(\zeta_{sc}) + c_1(\zeta_{sc})\,\alpha_e + c_2(\zeta_{sc})\,\alpha_e^2 + c_3(\zeta_{sc})\,\alpha_e^3 \quad (4)$$

These formulae determine the realistic relation:

$$R_p = b_{in} + (R_{\min,0} - b_{in})\exp(-\eta_e\mu_e) , \quad (5)$$

where η_e is expressed by Eq. (4) and

$$\alpha_e = -eR_pV_p / b_{in}\varepsilon_{in,e} , \quad \mu_e = b_{in}\left|eB_0\right| / \sqrt{2m_e\varepsilon_{in,e}} , \quad (6)$$

and R_{p0} is the closest radius in the absence of the magnetic field, which satisfies the following relation:

$$R_{p0}^2 - \alpha_e b_{in} R_{p0}\exp(-\zeta_{sc}R_{p0}/b_{in})] - b_{in}^2 = 0 . \quad (7)$$

As an example, the absorption cross-sections are shown in Fig. 1 as a function of the strength of the uniform magnetic field B_0 for the case R_p = 1 cm, $\varepsilon_{in,e}$ = 10 eV, (*a*) V_p = - 10 eV and (*b*) V_p = 10 V. In the case of negative applied voltage, (*a*) $V_p < 0$, the cross-sections at B_0 = 100 G increase from 1.57 cm^2 (ζ_{sc} = 0), 2.06 cm^2 (0.3), and 2.62 cm^2 (1.0) to 2.01 cm^2 (+28.1 %), 2.29 cm^2 (+11.8 %), and 2.69 cm^2 (+2.69 %), respectively. On the other hand for the positive applied voltage, (*b*) $V_p > 0$ the cross-sections decrease from 4.71 cm^2 (ζ_{sc} = 0), 4.36 cm^2 (0.3), and 3.77 cm^2 (1.0) to 3.98 cm^2 (- 15.5 %), 3.93 cm^2 (- 9.9 %), and 3.19 cm^2 (- 15.5 %), respectively. The relatively strong magnetic field enables an electron approach to the probe, which indicates the absorption cross-section increases or decreases for the case of negative and positive applied voltages, respectively. The plasma shielding has the same tendency. These effects make the absorption cross-section approach the geometrical cross-section of the probe $(= \pi R_p^2)$.

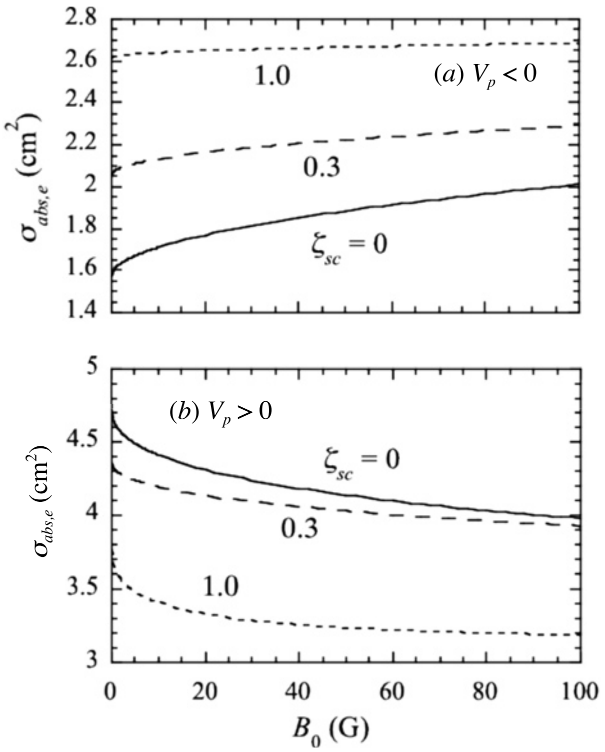

Fig. 1. Absorption cross-sections as a function of the strength of the uniform magnetic field B_0 for the case R_p = 1 cm, $\varepsilon_{in,e}$ = 10 eV, V_p = (*a*) - 10 eV and (*b*) 10 V.