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Correct values for high-frequency power absorption by inverse bremsstrahlung in plasmas

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(Received 16 October 1972)

Numerical corrections are made to previous values for the power absorption coefficient and some common errors noted.

Owing to recent strong interest in the heating of plasmas by lasers we would like to correct some numerical errors in the inverse bremsstrahlung absorption coefficient which appears in Refs. 1 and 2. The correct absorption coefficient is

$$K=\frac{16\pi Z^2 n_e n_i e^6 \ln\Lambda(\nu)}{3c\nu^2(2\pi m_e k_B T)^{3/2}(1-\nu_p^2/\nu^2)^{1/2}} \tag{1a}$$

or

$$K=\frac{7.8\times10^{-9} Z n_e^2 \ln\Lambda(\nu)}{\nu^2(k_BT)^{3/2}}\,\frac{1}{(1-\nu_p^2/\nu^2)^{1/2}}, \tag{1b}$$

where k_BT is in eV, $\Lambda(\nu)=$minimum of $v_T/\omega_p p_{\min}$, $v_T/\omega p_{\min}$. Here, Ze and n_i are the ionic charge and density, $-e$, m_e, n_e are electronic charge, mass, and number density, c is the velocity of light, v_T is the thermal velocity of the electrons, $p_{\min}$ is the minimum impact parameter for electron–ion collisions [$p_{\min}\cong$ maximum of Ze^2/k_BT or $\hbar/(m_ek_BT)^{1/2}$].

The above formula is a factor of 3 smaller than that given in Eqs. (26) and (27) of Ref. 1; that error was due to a numerical mistake in going from Eq. (24) (which is correct) to Eq. (27) of Ref. 1. This factor of 3 was corrected in Eqs. (6) and (6a) of Ref. 2. Unfortunately, a second error was made, the square was dropped from $\Lambda^2(\nu)$ in the $\ln\Lambda^2(\nu)$ term. Thus, the correct absorption coefficient is twice that given in Ref. 2.

These corrections bring the value for the constant multiplying $\ln\Lambda(\nu)$ into agreement with that used by Basov and Krokhin,[3] and also into agreement with that obtained by using Shkarofsky's[4] Coulomb collision frequency (ν_{ei}) and $K=(\nu_{ei})\nu_p^2/c\nu^2$.

While on this subject it seems worthwhile to point out two common errors in high-frequency power absorption formulas found in the literature. First, at frequencies well above the plasma frequency ν_p, $\ln\Lambda(\nu)$ should contain the wave frequency ν, rather than the plasma frequency ν_p, as prescribed in Ref. 1. Second, the Spitzer[5] electron–electron correction factor γ_E is for low-frequency use [$\nu\ll(\nu_{ei})$] only. Often writers confuse the formulas for high-frequency heating and for low-frequency diffusion or equipartition processes, for which electron–electron effects are important and $\ln\Lambda$ contains the plasma frequency rather than a wave frequency.

The Institute de Recherche de l'Hydro-Quebec supported the work by one of the authors (TWJ), the work by the other (JMD) was supported by U.S. Atomic Energy Commission Contract AT(11-1)-3073.

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[5] L. Spitzer, *Physics of Fully Ionized Gases* (Interscience, New York, 1956) p. 84 Table 5:4.