I. PHYSICAL CONSTANTS (2006)

$$
\begin{aligned}
G &= 6.674\,28\,(67) \times 10^{-8}\ \mathrm{cm}^3\ \mathrm{g}^{-1}\ \mathrm{s}^{-2} \\
c &= 2.997\,924\,58 \times 10^{10}\ \mathrm{cm\ s}^{-1} \quad \text{(exact)} \\
e &= 4.803\,204\,27\,(12) \times 10^{-10}\ \left(\mathrm{g\ cm}^3\ \mathrm{s}^{-2}\right)^{1/2} = 1.602\,176\,487(40) \times 10^{-19}\ \mathrm{C} \\
\hbar &= 1.054\,571\,628(53) \times 10^{-27}\ \mathrm{g\ cm}^2\ \mathrm{s}^{-1} \\
h &= 6.626\,068\,96(33) \times 10^{-27}\ \mathrm{g\ cm}^2\ \mathrm{s}^{-1} \\
m_e &= 9.109\,382\,15(45) \times 10^{-28}\ \mathrm{g} = 0.510\,998\,910(13)\ \mathrm{MeV} \\
m_p &= 1.672\,621\,637(83) \times 10^{-24}\ \mathrm{g} = 938.272\,31\ \mathrm{MeV} = 1.007\,276\,466\,77\,(10) m_u \\
m_n &= 1.674\,927\,211(84) \times 10^{-24}\ \mathrm{g} = 939.565\,346\,(23)\ \mathrm{MeV} \\
m_u &= 1\ \mathrm{amu} = 1.660\,538\,782(83) \times 10^{-24}\ \mathrm{g} = 931.494\,028(23)\ \mathrm{MeV} \\
\frac{m_p}{m_e} &= 1836.152\,672\,47(80) \\
\frac{m_u}{m_e} &= 1822.888\,484\,99\,(77) \\
\alpha^{-1} &= \frac{\hbar c}{e^2} = 137.035\,999\,679(94) \\
r_e &= \frac{e^2}{m_e c^2} = 2.817\,940\,2894(58) \times 10^{-13}\ \mathrm{cm} \\
a_0 &= \frac{\hbar^2}{m_e e^2} = 0.529\,177\,208\,59(36) \times 10^{-8}\ \mathrm{cm} \\
v_0 &= \frac{e^2}{\hbar} = 2.187\,691\,2541\,(15) \times 10^{8}\ \mathrm{cm\ s}^{-1} \\
\mathrm{Ry} &= I_H = \frac{m_e e^4}{2\hbar^2} = \frac{1}{2}\alpha^2 m_e c^2 = 13.605\,691\,93(34)\ \mathrm{eV} \\
\lambda\!\!\!^{-}_C &= \frac{\hbar}{m_e c} = 3.861\,592\,6459(53) \times 10^{-11}\ \mathrm{cm} \\
\sigma_T &= \frac{8\pi}{3} r_e^2 = 6.652\,458\,558(27) \times 10^{-25}\ \mathrm{cm}^2 \\
k &= 1.380\,6504\,(24) \times 10^{-16}\ \mathrm{erg\ K}^{-1} \\
\sigma &= 5.670\,400(40) \times 10^{-5}\ \mathrm{erg\ cm}^{-2}\ \mathrm{s}^{-1}\ \mathrm{K}^{-4} = 1.0283 \times 10^{12}\ \mathrm{erg\ cm}^{-2}\ \mathrm{s}^{-1}\ \mathrm{eV}^{-4}
\end{aligned}
$$

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$$
a = \frac{4\sigma}{c} = \frac{\pi^2}{15\hbar^3 c^3} k^4 = 7.565\,917 \times 10^{-15}\ \mathrm{erg\ cm}^{-3}\ \mathrm{K}^{-4}
$$

$$
\begin{aligned}
1\ \mathrm{eV} &= 11604.45\ \mathrm{K} = 1.602\,176\,487(40) \times 10^{-12}\ \mathrm{erg} \\
h\nu &= 12398.4188\ [\mathrm{eV}]/\lambda\ [\mathring{\mathrm{A}}] \\
1\ \mathrm{C} &= 2.997\,924\,58 \times 10^{9}\ \mathrm{ESU} \quad \text{(exact)} \\
e_{\mathrm{CGS}} &= 2\,997\,924\,580\, e_{\mathrm{SI}} \\
1\ \mathrm{pc} &= 3.0856 \times 10^{18}\ \mathrm{cm} \\
1\ \mathrm{AU} &= 1.495\,985 \times 10^{13}\ \mathrm{cm} \\
1\ \mathrm{year} &= 3.155\,692\,6 \times 10^{7}\ \mathrm{s} \\
M_\odot &= 1.989 \times 10^{33}\ \mathrm{g}; \qquad R_\odot = 6.959\,8 \times 10^{10}\ \mathrm{cm}; \qquad L_\odot = 3.90 \times 10^{33}\ \mathrm{erg\ s}^{-1} \\
M_\oplus &= 5.977 \times 10^{27}\ \mathrm{g}; \qquad R_\oplus = 6.371\,03 \times 10^{8}\ \mathrm{cm}
\end{aligned}
$$

Specific conductivity: $\sigma[\mathrm{s}^{-1}] = \dfrac{8.987\,55 \times 10^{11}}{\eta[\mathrm{Ohm\ cm}]}$

II. THERMODYNAMICS

The principal thermodynamic identity

$$\left(\frac{\partial E}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P = T^2\left[\frac{\partial}{\partial T}\left(\frac{P}{T}\right)\right]_V, \quad \text{or} \quad \rho^2\left(\frac{\partial \epsilon}{\partial \rho}\right)_T = P - T\left(\frac{\partial P}{\partial T}\right)_\rho. \tag{1}$$

Adiabatic sound velocity

$$c_s^2 \equiv \left(\frac{\partial P}{\partial \rho}\right)_S = \left(\frac{\partial P}{\partial \rho}\right)_T + \frac{T}{\rho^2}\frac{(\partial P/\partial T)_\rho^2}{(\partial \epsilon/\partial T)_\rho}. \tag{2}$$

If the pressure is given as $P = P(\rho, \epsilon)$, then

$$c_s^2 = \left(\frac{\partial P}{\partial \rho}\right)_\epsilon + \frac{P}{\rho^2}\left(\frac{\partial P}{\partial \epsilon}\right)_\rho. \tag{3}$$

Heat capacity

$$c_v = \left(\frac{\partial \epsilon}{\partial T}\right)_\rho > 0; \quad c_p = c_v + \frac{T}{\rho^2}\frac{(\partial P/\partial T)_\rho^2}{(\partial P/\partial \rho)_T}. \tag{4}$$

III. APPROXIMATE FORMULAE FOR THE IDEAL FERMI-GAS OF FREE ELECTRONS

Let n_e be the number of free electrons per unit volume. Then, the Fermi energy of the ideal free-electron gas is given by

$$E_F = \frac{1}{2}\left(3\pi^2\right)^{2/3}\frac{\hbar^2}{m_e}n_e^{2/3} = 26.0\left(\frac{\rho Z}{A}\right)^{2/3} \text{[eV]}. \tag{5}$$

If we define the dimensionless electron temperature as

$$\theta_e = \frac{T_e}{E_F}, \tag{6}$$

then the specific (per one electron) Helmholtz free energy of this gas can to a good accuracy be evaluated as

$$f_e = \frac{3}{5}E_F - \frac{3}{2}T_e \ln\left(1 + a\theta_e\right), \tag{7}$$

where a is a fitting parameter. The exact cold asymptotics $f_e \to \frac{3}{5}E_F$ as $\theta_e \to 0$ is ensured for any value of a. The exact Maxwellian asymptotics in the limit of $\theta_e \to \infty$ is recovered for

$$a = \frac{3}{2}\left(\frac{\pi e^2}{6}\right)^{1/3} = 2.3547987\ldots, \tag{8}$$

where $e = 2.71828\ldots$ is Euler's e number. From Eq. (7) one calculates the pressure

$$p_e = -\left(\frac{\partial f_e}{\partial n_e^{-1}}\right) = n_e\left(\frac{2}{5}E_F + T_e\frac{a\theta_e}{1 + a\theta_e}\right) \tag{9}$$

and the specific (per one electron) internal energy

$$\epsilon_e = f_e - T_e\left(\frac{\partial f_e}{\partial T_e}\right) = \frac{3}{2}\frac{p_e}{n_e} = \frac{3}{5}E_F + \frac{3}{2}T_e\frac{a\theta_e}{1 + a\theta_e}. \tag{10}$$

The chemical potential μ_e and the specific (per one electron) entropy s_e are given by

$$\mu_e = f_e + \frac{p_e}{n_e} = E_F + T_e\left[\frac{a\theta_e}{1 + a\theta_e} - \frac{3}{2}\ln\left(1 + a\theta_e\right)\right], \tag{11}$$

$$s_e = \frac{\epsilon_e - f_e}{T_e} = \frac{3}{2}\left[\frac{a\theta_e}{1 + a\theta_e} + \ln\left(1 + a\theta_e\right)\right]. \tag{12}$$

For $a = 2.35479\ldots$ the relative error of Eq. (9) (compared to exact Fermi integrals) never exceeds 2.6%; if the exact Maxwellian limit for f_e and μ_e is not of principal importance, the accuracy of Eq. (9) can be improved to 1.5% by setting $a = 5/2$.

IV. PLASMA PHYSICS

Plasma frequency

$$\omega_{pe}^2 = \frac{4\pi e^2 n_e}{m_e} = \ldots, \tag{13}$$

$$\hbar\omega_{pe} = 3.713307 \times 10^{-11}\sqrt{n_e}\ [\text{eV}]; \quad n_e \text{ is in cm}^{-3}. \tag{14}$$

Plasma critical density

$$n_{e,cr} = \pi\frac{m_e c^2}{\lambda^2 e^2} = 1.114854 \times 10^{21}\ \lambda_{\mu m}^{-2}\ [\text{cm}^{-3}], \tag{15}$$

where $\lambda_{\mu m}$ is the wavelength of the electromagnetic wave in micrometers.

V. ISOTOPES

Mass $= M$ (in atomic units), includes the mass of atomic electrons; natural abundance $= \delta$.

$\mathrm{H} = {}^1\mathrm{H}$:	$M = 1.007\,825\,035(12)$	
$\mathrm{D} = {}^2\mathrm{H}$:	$M = 2.014\,101\,779(24)$	$\delta = 1.15(70) \times 10^{-4}$
$\mathrm{T} = {}^3\mathrm{H}$:	$M = 3.016\,049\,27(4)$	$t_{1/2} = 12.33\mathrm{y}$
${}^3\mathrm{He}$:	$M = 3.016\,029\,31(4)$	$\delta = 1.37(3) \times 10^{-6}$
${}^4\mathrm{He}$:	$M = 4.002\,603\,24(5)$	
${}^6\mathrm{Li}$:	$M = 6.015\,121\,4(7)$	$\delta = 7.59(4)\%$
${}^7\mathrm{Li}$:	$M = 7.016\,003\,0(9)$	$\delta = 92.41(4)\%$
${}^9\mathrm{Be}$:	$M = 9.012\,181\,2(4)$	$\delta = 100\%$
${}^{10}\mathrm{B}$:	$M = 10.012\,936\,9(3)$	$\delta = 19.9(7)\%$
${}^{11}\mathrm{B}$:	$M = 11.009\,305\,4(4)$	$\delta = 80.1(7)\%$