~~ボルツマン定数、プランク定数と温度~~

The Boltzmann constant, the Planck constant and the Temperature*

Yoshio TAKEMOTO**, Seishu SHIMAMOTO***

Department of Mechanical and Electrical Engineering, School of Engineering,
Nippon Bunri University

Abstract

The Boltzmann constant and the Planck constant is "independent". Planck's law describes the amount of electromagnetic radiational energy $B_\nu(\nu,T)=\frac{2h\nu^3}{c^2}\frac{1}{e^{\frac{h\nu}{k_BT}}-1}$ emitted by the black body in thermal equilibrium at a definite temperature. Where k_B is the Boltzmann constant, h is the Planck constant, and c is the speed of light in the medium, whether material or vacuum.

In this paper, we define the temperature by the frequency of the light radiated from a particle and it cleared the meaning of the Shimamoto relation "$k_B=\frac{h}{ec}$" between the k_B (the Boltzmann constant) and h (the Planck constant).

1. Preliminaries

(i) The Boltzmann constant

The Boltzmann constant k_B is a physical constant relating energy and temperature at the individual particle level.

It is the gas constant R divided by the Avogadro constant N_A.

(ii) The Planck constant

The Planck constant h was originally the proportionality constant between the energy E and the frequency ν of light.

(iii) $PV=nRT$

The ideal gas law is the equation of state of a hypothetical ideal gas.

P is the pressure of the gas.

V is the volume of the gas.

n is the amount of substance of gas (in moles).

R is the ideal gas constant, equal to the product of the Boltzmann constant and the Avogadro constant.

T is the temperature of the gas which can be derived microscopically from kinetic theory.

2. The electron orbit which considered the Planck constant $\hbar$ $\left(= m_e r_1 \dfrac{v_1}{\sqrt{1-(\frac{v_1}{c})^2}} = m_e r_1 u_1 : momentum\right)$ in the Atomic shell

In this paper, we assume the angular moment of electron is constant in the atomic shell.

(In the case A)

The first electron around the n-proton with $q(=ne)$ charge.

We assume the angular moment is the same value as the Planck constant and the orbit is a circle, then

(i) By the balance in the circle $\dfrac{m_e v^2}{r} = \dfrac{k_0 e q}{r^2} (= \dfrac{n k_0 e^2}{r^2}) \quad \therefore m_e r v^2 = n k_0 e^2$.

$$\therefore (\frac{v}{c})^2 = \frac{n k_0 e^2}{m_e r c^2} = \frac{n R_0}{r} \quad , R_0 = \frac{k_0 e^2}{m_e c^2}$$

(ii) By the hypothesis, the angular moment is $m_e r v = m_e r_1 v_1 \fallingdotseq \hbar (= m_e r_1 u_1) \quad \therefore v \fallingdotseq \dfrac{\hbar}{m_e r}$

By the relation (i),(ii).

$$\frac{n R_0}{r} [= (\frac{v}{c})^2] \fallingdotseq (\frac{\hbar}{m_e r c})^2 \quad \therefore r \fallingdotseq \frac{1}{n} \frac{\hbar^2}{m_e{}^2 c^2 R_0} = \frac{1}{n} r_1 .$$

$$r_1 = \frac{\hbar^2}{m_e{}^2 c^2 R_0} = \frac{\hbar^2}{m_e k_0 e^2} = 5.29166 \times 10^{-11} \quad , v \fallingdotseq \frac{\hbar}{m_e r} = n \frac{\hbar}{m_e r_1} = n v_1 .$$

Then, the energy of the electron around the proton is

$$E = m_e c C_0 = \frac{m_e c^2}{\sqrt{1-(\frac{v}{c})^2}} e^{-\frac{nR_0}{r}} \fallingdotseq \frac{m_e c^2}{\sqrt{1-(\frac{n v_1}{c})^2}} e^{-\frac{n^2 R_0}{r_1}}$$

$$= m_e c^2 (1 + \frac{1}{2} \frac{n^2 R_0}{r_1} + \cdots)(1 - \frac{n^2 R_0}{r_1} + \cdots) = m_e c^2 (1 - \frac{n^2}{2} \frac{R_0}{r_1} + \cdots) .$$

Therefore, the formula of the n-th ionization energy $X^{+(n-1)} \to X^{+n}$ is

$$N_A (m_e c^2 - E)/1000 = N_A (m_e c^2 - \frac{m_e c^2}{\sqrt{1-(\frac{n v_1}{c})^2}} e^{-\frac{n^2 R_0}{r_1}})/1000 = 1312.7 \times n^2 ,$$

where $N_A = 6.02214 \times 10^{23}$ is the Avogadro number and X^{+n} means the bare atomic nucleus.

Table 1. Ionization energy and calculated I.E. and radius.

Atom	H	He	Li	Be	B	C	N	O	F	Ne
I.E.	**1312.0**	**5250.3**	11814.7	21006.6	32826.7	47277.0	64360.0	84078.0	106434.3	131432.0
Calculated I.E.	**1312.7**	**5250.8**	11814.3	21003.2	32817.5	47257.2	64322.3	84012.8	106328.7	131270.0

Radius×10^(-11)	5.292	2.646	1.764	1.323	1.058	0.882	0.756	0.661	0.588	0.529

In the case of hydrogen, the orbit is an oval. Because the solutions of the "orbit equation"

$$(\frac{C}{r})^2 - {C_0}^2 e^{2\frac{R_0}{r}} + c^2 = 0$$

are $r1 = 5.16491\times10^{-11}$ (perihelion) and $r2 = 5.42420\times10^{-11}$ (aphelion), where $E_1 = m_e c C_0 = m_e c^2 - 1312.0\times1000/N_{A[kgm^2/s^2]}$ is an orbit energy and $C = r_1 v_1 = 1.15768\times10^{-4}_{[m^2/s]}$ is a speed of area.

Therefore the orbital eccentricity is 0.0244865.

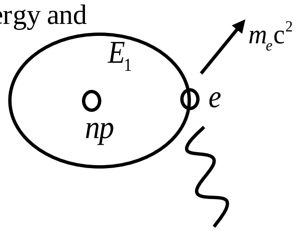


Fig. 1. The orbit of first electron.

(In the case **B**)

The second electron around the n-proton with $q(=ne)$ charge.

We assume the angular moment is the same value as the Planck constant and the orbit is an opposite point in a common circle, then

(i) By the balance in the circle $\frac{m_e v^2}{r} = \frac{nk_0e^2}{r^2} - \frac{k_0e^2}{(2r)^2}$ $\therefore m_e r v^2 = \frac{4n-1}{4} k_0 e^2$.

$$\therefore (\frac{v}{c})^2 = \frac{4n-1}{4}\frac{ke^2}{m_e r c^2} = \frac{4n-1}{4}\frac{R_0}{r}$$

(ii) By the hypothesis, the angular moment is $m_e r v = m_e r_1 v_1 \fallingdotseq \hbar (= m_e r_1 u_1)$ $\therefore v \fallingdotseq \frac{\hbar}{m_e r}$

By the relation (i),(ii).

$$\frac{4n-1}{4}\frac{R_0}{r} (= (\frac{v}{c})^2) \fallingdotseq (\frac{\hbar}{m_e r c})^2 .$$

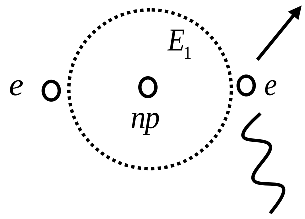


Fig. 2. The orbit of second electron.

$$\therefore r \fallingdotseq \frac{4}{4n-1}\frac{\hbar^2}{{m_e}^2 c^2 R_0} = \frac{4}{4n-1} r_1 \quad , v \fallingdotseq \frac{\hbar}{m_e r} = \frac{4n-1}{4}\frac{\hbar}{m_e r_1} = \frac{4n-1}{4} v_1 .$$

Then, the energy of the electron around the proton is

$$E_1 = m_e c C_0 = \frac{m_e c^2}{\sqrt{1-(\frac{v}{c})^2}} e^{-\frac{nk_0e^2}{m_ec^2r}+\frac{k_0e^2}{m_ec^2(2r)}} = \frac{m_e c^2}{\sqrt{1-(\frac{v}{c})^2}} e^{-\frac{2n-1}{2r}\frac{k_0e^2}{m_ec^2}} \fallingdotseq \frac{m_e c^2}{\sqrt{1-(\frac{4n-1}{4}\frac{v_1}{c})^2}} e^{-\frac{2n-1}{2}\frac{4n-1}{4}\frac{R_0}{r_1}}$$

$$= m_e c^2 (1 + \frac{1}{2}(\frac{4n-1}{4})^2 \frac{R_0}{r_1} - \frac{(2n-1)(4n-1)}{2\cdot4}\frac{R_0}{r_1} + \cdots) = m_e c^2 (1 - \frac{(4n-1)(4n-3)}{32}\frac{R_0}{r_1} + \cdots) .$$

Therefore, the formula of $(n-1)$-th ionization energy $X^{+(n-2)} \to X^{+(n-1)}$ is

$$N_A(m_e c^2 - E)/1000 = N_A(m_e c^2 - \frac{m_e c^2}{\sqrt{1-(\frac{4n-1}{4}\frac{v_1}{c})^2}} e^{-\frac{2n-1}{2}\frac{4n-1}{4}\frac{R_0}{r_1}})/1000 .$$

Table 2. Ionization energy and calculated I.E. ratio and radius.

Atom	He	Li	Be	B	C	N	O	F	Ne
I. E.	2372.3	7298.0	14848.7	25025.8	37831.0	53266.6	71330.0	92038.1	115379.5
Calculated I. E.	2871.3	8120.1	15990.0	26476.8	39575.3	55279.1	73580.4	94470.1	117937.9
Ratio	1.21	1.11	1.08	1.06	1.05	1.04	1.03	1.03	1.02
Radius×10^(-11)	3.024	1.924	1.411	1.114	0.9203	0.7840	0.6828	0.6048	0.5427

This difference between I. E. and the calculated value is caused by the orbit's being an oval and twin star style. In the case of Helium, the solutions of the "orbit equation"

$$(\frac{C}{r})^2 - {C_0}^2 e^{2^{2}\frac{3R_0}{2r}} + c^2 = 0$$

are $r1 = 2.44321\times10^{-11}$ (perihelion) and $r2 = 6.34106\times10^{-11}$ (aphelion),

where $E_2 = m_e cC_0 = m_e c^2 - 2372.3\times1000/N_{A[kgm^2/s^2]}$ is an orbit energy

and $C = r_1 v_1 = 1.15768\times10^{-4}{}_{[m^2/s]}$ is a speed of area.

Therefore the orbital eccentricity is 0.443731.

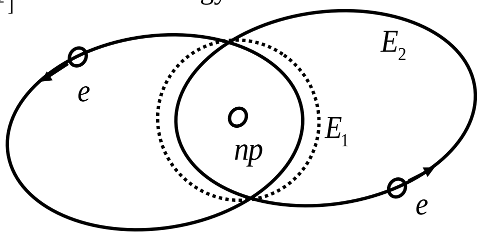


Fig. 3. The twin orbit of second electron.

In the case of Lithium, the solutions of the "orbit equation"

$$(\frac{C}{r})^2 - {C_0}^2 e^{2^{2}\frac{5R_0}{2r}} + c^2 = 0$$

are $r1 = 1.42613\times10^{-11}$ (perihelion) and $r2 = 4.11025\times10^{-11}$ (aphelion),

where $E_2 = m_e cC_0 = m_e c^2 - 7298.0\times1000/N_{A[kgm^2/s^2]}$ is an orbit energy

and $C = r_1 v_1 = 1.15768\times10^{-4}{}_{[m^2/s]}$ is a speed of area.

Therefore the orbital eccentricity is 0.484815. And so on.

(In the case **C**)

The third electron around the n-proton with $q\,(= ne)$ charge.

We assume the angular moment is the same value as the Planck constant, then we get the oval orbit by the ionization energy data.

Therefore, table 3 shows the energy of ($n-1$)-th ionization energy $X^{+(n-3)} \to X^{+(n-2)}$.

Table 3. The measurement value of I. E..

Atom	Li	Be	B	C	N	O	F	Ne
I. E.	520.2	1757.1	3659.7	6222.7	9444.9	13326.5	17868.0	23069.5

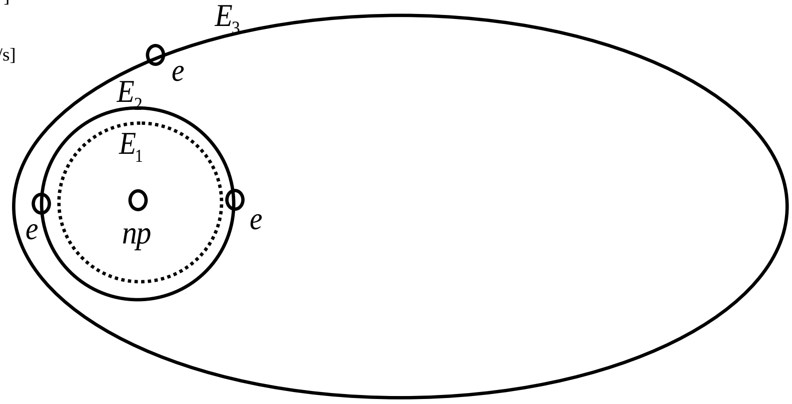
Generally, we get the orbit of the electron by the I. E. value and the Planck constant or speed of area which value is the same resonance value of all electrons.

In the case of Lithium, the solutions of the "orbit equation"

$E_3 = m_e c C_0 = m_e c^2 - 520.2 \times 1000/N_{A[kgm^2/s^2]}$ and

the speed of area $C = r_1 v_1 = 1.15768 \times 10^{-4}{}_{[m^2/s]}$

$$(\frac{C}{r})^2 - C_0{}^2 e^{2^{\frac{R_0}{r}}} + c^2 = 0$$



are $r1 = 8.02322 \times 10^{-11}$ (perihelion)

and $r2 = 2.24788 \times 10^{-10}$ (aphelion) in approximate way,

where $E_3 = m_e c C_0 = m_e c^2 - 520.2 \times 1000/N_{A[kgm^2/s^2]}$ is an orbit energy

and $C = r_1 v_1 = 1.15768 \times 10^{-4}{}_{[m^2/s]}$ is a speed of area.

Fig. 4. The orbit of third electron.

Therefore the orbital eccentricity is 0.473922 .

And In the case of Beryllium, the solutions of the "orbit equation"

$$(\frac{C}{r})^2 - C_0{}^2 e^{2^{\frac{2R_0}{r}}} + c^2 = 0$$

are $r1 = 3.85957 \times 10^{-11}$ (perihelion) and $r2 = 1.39526 \times 10^{-10}$ (aphelion) in approximate,

where $E_3 = m_e c C_0 = m_e c^2 - 1757.1 \times 1000/N_{A[kgm^2/s^2]}$ is an orbit energy

and $C = r_1 v_1 = 1.15768 \times 10^{-4}{}_{[m^2/s]}$ is a speed of area.

Therefore the orbital eccentricity is 0.566637 .

And In the case of Boron, the solutions of the "orbit equation"

$$(\frac{C}{r})^2 - C_0{}^2 e^{2^{\frac{3R_0}{r}}} + c^2 = 0$$

are $r1 = 2.47546 \times 10^{-11}$ (perihelion) and $r2 = 1.02282 \times 10^{-10}$ (aphelion) in approximate way,

where $E_3 = m_e c C_0 = m_e c^2 - 3659.7 \times 1000/N_{A[kgm^2/s^2]}$ is an orbit energy

and $C = r_1 v_1 = 1.15768 \times 10^{-4}{}_{[m^2/s]}$ is a speed of area.

Therefore the orbital eccentricity is 0.610276 . And so on.

3. The meaning of the temperature

We transform the equation of state of an ideal gas $PV = nRT = nN_A k_B T$ to the “matrix form” as follows:

(i) PV (the left side of equation)

The force is $f_{x[kgm/s^2]} = p_{[kgm/s^2/m^2]} \cdot S_{yz[m^2]} = -\mathrm{i}p_{[kgm/s^2/m^2]} \cdot \mathrm{i}S_{yz[m^2]}$ where , $\mathrm{i}p_{[kgm/s^2/m^2]}$ is a pressure. Therefore

$${}^{-}\begin{bmatrix}0 & \\ & f_{x[kgm/s^2]}\end{bmatrix}^{-} = {}^{-}\begin{bmatrix}-\mathrm{i}p_{[kgm/s^2/m^2]} & \\ & 0\end{bmatrix}^{-} {}^{+}\begin{bmatrix}0 & \\ & \mathrm{i}S_{yz[m^2]}\end{bmatrix}^{-} \quad , S_{yz[m^2]} = L_{y[m]} \cdot L_{z[m]}$$

$$= {}^{-}\begin{bmatrix}-\mathrm{i}p_{[kgm/s^2/m^2]} & \\ & 0\end{bmatrix}^{-} {}^{+}\begin{bmatrix}0 & \\ & -L_{y[m]}\end{bmatrix}^{+} {}^{-}\begin{bmatrix}0 & \\ & L_{z[m]}\end{bmatrix}^{-}$$

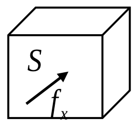


Fig. 5. The pressure.

Then, energy PV is

$${}^{-}\begin{bmatrix}\underline{\underline{-f_{[kgm/s^2]}L_{[m]}}} & \\ & 0\end{bmatrix}^{+} = {}^{-}\begin{bmatrix}0 & \\ & f_{x[kgm/s^2]}\end{bmatrix}^{-} {}^{+}\begin{bmatrix}0 & \\ & -L_{x[m]}\end{bmatrix}^{+}$$

$$= \underbrace{{}^{-}\begin{bmatrix}-\mathrm{i}p_{[kgm/(s^2/m^2)]} & \\ & 0\end{bmatrix}^{-}}_{p} \underbrace{{}^{+}\begin{bmatrix}0 & \\ & \mathrm{i}S_{yz[m^2]}\end{bmatrix}^{-} {}^{+}\begin{bmatrix}0 & \\ & -L_{x[m]}\end{bmatrix}^{+}}_{V}$$

And $nN_A k_B T$ (the right side of equation) is transformed as follows:

We take the only one particle. Then $nN_A = 1$, therefore $nN_A k_B T = k_B T$.

In this situation, we pay attention to the "Shimamoto relation" which is the relation between the Boltzmann constant and the Plank constant

$$k_{B[kgm/Ks^2]} = \frac{h_{[kgm^2/s]}}{ec_{[Cm/s]}} = \frac{2\pi m_{e[kg]} r_{1[m]} v_{1[m/s]}}{e_{[C]} c_{[m/s]}} \left(\fallingdotseq \frac{2\pi m_{e[kg]} r_{1[m]} u_{1[m/s]}}{e_{[C]} c_{[m/s]}}\right) .$$

And we define “the Boltzmann” as

$$\overrightarrow{k_B} = \frac{2\pi\gamma_1\beta_1}{e_{[C]} c_{[m/s]}} {}^{-}\begin{bmatrix}0 & \\ & (r_1, 0, 0)\end{bmatrix}^{-}_{[m]} {}^{+}\begin{bmatrix}m_e u_0 & \\ & -(0, m_e u_1, 0)\end{bmatrix}^{+}_{[kgm/s]}$$

$$= \frac{2\pi\gamma_1\beta_1}{e_{[C]} c_{[m/s]}} {}^{-}\begin{bmatrix}0 & \\ & (m_e r_1 \underline{u_0}, 0, \mathrm{i} m_e r_1 \underline{u_1})\end{bmatrix}^{+}_{[kgm^2/s]} , \quad \left|\overrightarrow{k_B}\right| = \frac{2\pi m_e r_1 u_1}{ec}$$

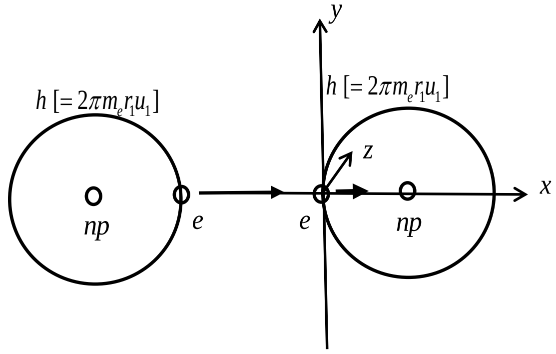
where $\dfrac{u_0}{\mathrm{c}} = \dfrac{dt}{d\mathrm{c}\tau} = \gamma_1$, $\dfrac{u}{\mathrm{c}} = \dfrac{\mathrm{d}r}{\mathrm{d}\mathrm{c}\tau} = \gamma_1\beta_1$, $u_0{}^2 - u^2 = \mathrm{c}^2$

Then the dimension of temperature $T_{[K]}$ is $T_{[K]} = \dfrac{PV}{k_B} = \dfrac{\boldsymbol{f}_{[kgm/s^2]} L_{[m]}}{\dfrac{2\pi m_{e[kg]} r_{1[m]} u_{1[m/s]}}{e_{[C]} \mathrm{c}_{[m/s]}}}$,

Then $[K] = [Cm/s^2]$.

Therefore, we define the temperature as the acceleration quantity, that is to say

$$\frac{\mathrm{d}}{\mathrm{d}\tau}\,{}^{-}\!\begin{bmatrix} e\gamma & \\ & (0, e\gamma\beta, 0) \end{bmatrix}^{-}_{[C/m]} = \frac{2\pi\vec{T}\gamma_1\beta_1}{e_{[C]}\mathrm{c}_{[m/s]}}\,{}^{-}\!\begin{bmatrix} e\gamma_1 & \\ & (0, e\gamma_1\beta_1, 0) \end{bmatrix}^{-}_{[C]}.$$



$$, e = {}^{-}\!\begin{bmatrix} e\gamma & \\ & e\gamma\beta \end{bmatrix}^{-}$$

Fig. 6. The collision of two particles.

Then

$$\vec{T}_{[K]} = \frac{e_{[C]}\mathrm{c}_{[m/s]}}{2\pi\gamma_1\beta_1}\frac{\mathrm{d}}{\mathrm{d}\tau}\,{}^{-}\!\begin{bmatrix} e\gamma & \\ & (0, e\gamma\beta, 0) \end{bmatrix}^{-}_{[C/s]} \cdot {}^{-}\!\begin{bmatrix} e\gamma_1 & \\ & (0, e\gamma_1\beta_1, 0) \end{bmatrix}^{-,-1}_{[/C]}$$

$$= \frac{e_{[C]}\mathrm{c}_{[m/s]}}{2\pi\gamma_1\beta_1}\,{}^{-}\!\begin{bmatrix} \dfrac{\mathrm{d}\gamma}{\mathrm{d}\tau}(=0) & \\ & (\dfrac{\mathrm{d}\gamma\beta}{\mathrm{d}\tau}, 0, 0) \end{bmatrix}^{-}_{[/s]}\,{}^{+}\!\begin{bmatrix} \gamma_1 & \\ & -(0, \gamma_1\beta_1, 0) \end{bmatrix}^{+}_{[-]}$$

$$= \frac{e\mathrm{c}}{2\pi}\,{}^{-}\!\begin{bmatrix} 0 & \\ & (\dfrac{\mathrm{d}\log\gamma\beta}{\mathrm{d}\tau}\underline{\gamma_1}, 0, \mathrm{i}\dfrac{\mathrm{d}\log\gamma\beta}{\mathrm{d}\tau}\underline{\gamma_1\beta_1}) \end{bmatrix}^{+}, \quad \left|\vec{T}\right| = \frac{e\mathrm{c}}{2\pi}\frac{\mathrm{d}\log\gamma\beta}{\mathrm{d}\tau}$$

Because, for simplicity $\beta_1 \bullet r_1 = 0$ ($\underline{\underline{\beta_1 \perp r_1}}$), and $\beta_1 \bullet \dfrac{\mathrm{d}\beta}{\mathrm{d}\tau} = 0$ ($\underline{\underline{\beta_1 \perp \dfrac{\mathrm{d}\beta}{\mathrm{d}\tau}}}$)

$$\frac{\mathrm{d}\gamma}{\mathrm{d}\tau} = \frac{\mathrm{d}}{\mathrm{d}\tau}\left(\frac{1}{\sqrt{1-(\frac{v}{\mathrm{c}})^2}}\right) = \frac{2(\frac{v_1}{\mathrm{c}})\bullet\frac{\mathrm{d}}{\mathrm{d}\tau}(\frac{v}{\mathrm{c}})}{1-(\frac{v_1}{\mathrm{c}})^2} = \frac{2(\frac{v_1}{\mathrm{c}})}{1-(\frac{v_1}{\mathrm{c}})^2}\bullet\frac{\mathrm{d}(\frac{v}{\mathrm{c}})}{\mathrm{d}\tau} = 2\gamma_1{}^2\beta_1\bullet\frac{\mathrm{d}\beta}{\mathrm{d}\tau}(=0)$$

$$\frac{\mathrm{d}\gamma\beta}{\mathrm{d}\tau} = \frac{\mathrm{d}}{\mathrm{d}\tau}\left(\frac{\frac{v_1}{c}}{\sqrt{1-(\frac{v_1}{c})^2}}\right) = \frac{\frac{\mathrm{d}}{\mathrm{d}\tau}(\frac{v_1}{c})}{\sqrt{1-(\frac{v_1}{c})^2}} = \gamma_1 \frac{\mathrm{d}\beta}{\mathrm{d}\tau}$$

Then the energy is

$$\underset{PV}{\underline{\underline{{}^{-}\begin{bmatrix} \boldsymbol{f}_{[kgm/s^2]}L_{[m]} & \\ & 0\end{bmatrix}^{+}}}}$$

$$= \underset{k_B}{\underline{\underline{\frac{2\pi u_1}{ec}\,{}^{-}\begin{bmatrix}0 & \\ & (m_e r_1\gamma_1, 0, \mathrm{i} m_e\gamma_1\beta_1)\end{bmatrix}^{+}}}} \cdot \underset{T}{\underline{\underline{\frac{ec}{2\pi}\,{}^{-}\begin{bmatrix}0 & \\ & (\frac{\mathrm{d}\log\gamma\beta}{\mathrm{d}\tau}\gamma_1, 0, \mathrm{i}\frac{\mathrm{d}\log\gamma\beta}{\mathrm{d}\tau}\gamma_1\beta_1)\end{bmatrix}^{+}}}}$$

$$= {}^{-}\begin{bmatrix} \underset{k_B}{\underline{\underline{\frac{2\pi m_e r_1 u_1}{ec}{}_{[kgm/C]}}}} \cdot \underset{T}{\underline{\underline{\frac{ec}{2\pi}\frac{\mathrm{d}\log\gamma\beta}{\mathrm{d}\tau}{}_{[Cm/s^2]}}}} & \\ & 0\end{bmatrix}^{+}_{[kgm^2/s^2]}$$

Because the time component is

$$\boldsymbol{f}_{[kgm/s^2]}L_{[m]}$$

$$= \frac{2\pi u_1}{ec}(m_e r_1\underline{\gamma_1}) \cdot \frac{ec}{2\pi}\left(\frac{\mathrm{d}\log\gamma\beta}{\mathrm{d}\tau}\underline{\gamma_1}\right) + \frac{2\pi u_1}{ec}(\mathrm{i}m_e r_1\underline{\gamma_1\beta_1}) \cdot \frac{ec}{2\pi}\left(\mathrm{i}\frac{\mathrm{d}\log\gamma\beta}{\mathrm{d}\tau}\underline{\gamma_1\beta_1}\right)$$

$$= \frac{2\pi u_1}{ec} m_e r_1 u_1 \cdot \frac{ec}{2\pi}\frac{\mathrm{d}\log\gamma\beta}{\mathrm{d}\tau}(\gamma_1{}^2 - (\gamma_1\beta_1)^2) \qquad ,\gamma_1{}^2 - (\gamma_1\beta_1)^2 = 1$$

$$= \underset{k_B}{\underline{\underline{\frac{2\pi m_e r_1 u_1}{ec}{}_{[kgm/C]}}}} \cdot \underset{T}{\underline{\underline{\frac{ec}{2\pi}\frac{\mathrm{d}\log\gamma\beta}{\mathrm{d}\tau}{}_{[Cm/s^2]}}}} \qquad ,T = \frac{ec}{2\pi}\frac{\mathrm{d}\log\gamma\beta}{\mathrm{d}\tau}{}_{[Cm/s^2]} \text{ (one particle)}$$

or

$$= \underset{h}{\underline{\underline{2\pi m_e r_1 u_{1[kgm^2/s]}}}} \cdot \underset{\nu}{\underline{\underline{\frac{\mathrm{d}\log\gamma\beta}{2\pi\mathrm{d}\tau}{}_{[/s]}}}} \qquad ,\nu = \frac{\mathrm{d}\log\gamma\beta}{2\pi\mathrm{d}\tau}{}_{[/s]}$$

And the space component is

$$-\mathrm{i}\frac{2\pi u_1}{ec}(m_e r_1\underline{\gamma_1}, 0, \mathrm{i}m_e r_1\underline{\gamma_1\beta_1}) \times \frac{ec}{2\pi}\left(\frac{\mathrm{d}\log\gamma\beta}{\mathrm{d}\tau}\underline{\gamma_1}, 0, \mathrm{i}\frac{\mathrm{d}\log\gamma\beta}{\mathrm{d}\tau}\underline{\gamma_1\beta_1}\right)$$

$$= -\mathrm{i}(0, -m_e r_1 u_1 \underline{\gamma_1} \cdot \mathrm{i}\frac{\mathrm{d}\log\gamma\beta}{\mathrm{d}\tau}\underline{\gamma_1\beta_1} + \mathrm{i}m_e r_1 u_1 \underline{\gamma_1\beta_1} \cdot \frac{\mathrm{d}\log\gamma\beta}{\mathrm{d}\tau}\underline{\gamma_1}, 0)$$

$$= (0, 0, 0)$$

Therefore, we get $PV = k_B T = h\nu$.

(Example 1)The one particle calculation

$$T = ec\sum_{mean}\frac{\mathrm{d}\log(\gamma\beta)}{2\pi\mathrm{d}\tau}_{[Cm/s^2]} = ec\sum_{mean}\nu = ec\frac{\nu_0}{2.82}, \nu_0$$ is a mode value.

The calculation of $\nu = \frac{\mathrm{d}\log(\gamma\beta)}{2\pi\mathrm{d}\tau}_{[/s]}$

When $T = ec\frac{\mathrm{d}\log(\gamma\beta)}{2\pi\mathrm{d}\tau} = 273.15(K)$, then

$$\nu = \frac{\mathrm{d}\log(\gamma\beta)}{2\pi\mathrm{d}\tau} = 5.68371\times 10^{12}{}_{[/s]}$$

And $\beta_1 = \frac{\nu_1}{\mathrm{c}} (=0.00729735)$, $\gamma_1\beta_1 = \frac{\frac{\nu_1}{\mathrm{c}}}{\sqrt{1-(\frac{\nu_1}{\mathrm{c}})^2}} (=0.00729755)$,

then $\frac{\mathrm{d}\gamma\beta}{2\pi\mathrm{d}\tau} = \gamma_1\beta_1\nu (= 2.60608\times 10^{11}{}_{[/s]})$

$$\boldsymbol{f}_{[kgm/s^2]} L_{[m]}$$

$$= \underbrace{2\pi m_e r_1 u_{1[kgm^2/s]}}_{h} \cdot \underbrace{\frac{\mathrm{d}\log\beta}{2\pi\mathrm{d}\tau}_{[/s]}}_{\nu}$$

$$= 6.62607\times 10^{-34}{}_{[kgm^2/s]} \times 5.68371\times 10^{12}{}_{[/s]} = 3.76607\times 10^{-21}{}_{[kgm^2/s^2]}$$

(Example 2) The kinetic energy

By the formula $\mathrm{d}E_J = \underline{\underline{\boldsymbol{f}_x}} \cdot \mathrm{d}x = \mathrm{c}e\boldsymbol{E}\mathrm{d}\tau_{[J]}$, we transform to the matrix.

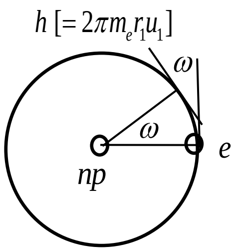


Fig. 7. The image of a particle.

$$\mathrm{d}\vec{E}_J = {}^{-}\begin{bmatrix} f_t & \\ & \underline{\underline{\boldsymbol{f}}} \end{bmatrix}^{-} \, {}^{+}\begin{bmatrix} \dfrac{\mathrm{dc}t}{\mathrm{d}\tau} & \\ & -\underline{\underline{\dfrac{\mathrm{d}\boldsymbol{r}}{\mathrm{d}\tau}}} \end{bmatrix}^{+} \underline{\underline{\mathrm{d}\tau}}$$

$$= {}^{-}\begin{bmatrix} -\underset{k_B}{\underline{\underline{\dfrac{2\pi m_e u_1 \mathrm{d}r}{e\mathrm{c}}{}_{[kgm/C]}}}} \cdot \underset{T}{\underline{\underline{\dfrac{e\mathrm{c}}{\gamma_1\beta_1}\dfrac{\mathrm{d}\gamma\beta}{2\pi\mathrm{d}\tau}{}_{[Cm/s^2]}}}} & \\ & 0 \end{bmatrix}^{+}$$

Then the time component is

$$\mathrm{d}E = \underset{k_B T}{\underline{\underline{\boldsymbol{f}_{[kgm/s^2]}\mathrm{d}L_{[m]}}}} = \underset{k_B}{\underline{\underline{\dfrac{2\pi m_e u_1 \mathrm{d}r}{e\mathrm{c}}{}_{[kgm/C]}}}} \cdot \underset{T}{\underline{\underline{e c\dfrac{\mathrm{d}\log\gamma\beta}{2\pi\mathrm{d}\tau}{}_{[Cm/s^2]}}}}$$

$$\therefore \frac{\mathrm{d}E}{\mathrm{d}\tau} = (f_{[kgm/s^2]}, 0, 0)\cdot\left(\frac{\mathrm{d}L}{\mathrm{d}\tau}{}_{[m/s]}, 0, 0\right) = \left(2\pi m_e u_1 \frac{\mathrm{d}r}{\mathrm{d}\tau}{}_{[kgm^2/s^2]}, 0, 0\right)\cdot\left(\frac{\mathrm{d}\log\gamma\beta}{2\pi\mathrm{d}\tau}{}_{[/s]}, 00\right)$$

$$= \left(m_e\mathrm{c}^2\gamma_1\beta_1\frac{\mathrm{d}r}{\mathrm{dc}\tau}, 0, 0\right)\cdot\left(\frac{1}{\gamma_1\beta_1}\frac{\mathrm{d}\gamma\beta}{\mathrm{d}\tau}, 0, 0\right) = \left(m_e\mathrm{c}^2\frac{\mathrm{d}r}{\mathrm{dc}\tau}, 0, 0\right)\cdot\left(\frac{\mathrm{d}\gamma\beta}{\mathrm{d}\tau}, 0, 0\right)$$

$$= \left(m_e\mathrm{c}^2\gamma_x\beta_x\frac{\mathrm{d}\gamma\beta}{\mathrm{d}\tau}, 0, 0\right) = \frac{1}{2}m_e\mathrm{c}^2\left(\frac{\mathrm{d}(\gamma_x\beta_x)^2}{\mathrm{d}\tau}, 0, 0\right).$$

$$\therefore E(= PV) = \boldsymbol{f}_{[kgm/s^2]}L_{[m]} = \frac{1}{2}m_e\mathrm{c}^2(\gamma_x\beta_x)^2 \fallingdotseq \frac{1}{2}m_e v_x{}^2 \quad \text{which is one way quantity.}$$

4. Conclusion

The electron is move at the resonance point which is expressed by the angular moment (or Planck constant) of the electric field.

Temperature is the frequency of light which has been caused by collision of a particle.

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