The Photon Impact

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Abstract

The impact of a photon hitting a surface is determined. Newton law of dynamics is demonstrated from thermodynamics considerations in which Planck oscillator is considered as a 4-space dimensions oscillator. Wave-corpuscle duality is remodeled.

Key words: Photon impact, fundamental law of dynamics, Planck oscillator, absolute time, 5-dimensions Universe, wave-corpuscle duality.

1-Introduction :

The "radiancy" of a black body is given by Cardoso & de Castro law as a generalized Stefan-Boltzmann law in $D - Dimensional$ Universe [1]:

$E_T = R_T = \sigma_D T^{D+1}$ (1)

With $\sigma_D = \left(\frac{2}{c}\right)^{D-1} (\sqrt{\pi})^{D-2} \frac{k^{D+1}}{h^D} D(D-1)\Gamma(\frac{D}{2})\zeta(D+1)$: generalized Stefan-Boltzmann constant .

D : spatial dimension of the Universe.

-For $D = 3$ we have $\sigma_3 = \sigma = \frac{2\pi^5 k^4}{15c^2 h^3}$: Stefan-Boltzmann constant given in thermo dynamical analysis and proved by experience.

-For $D = 4$

$$E = \frac{4\pi k^5}{c^3 h^4} T^5 \zeta(5)\Gamma(5) \approx \frac{120k^5}{c^3 h^4} T^5 \qquad (2)$$

We can obtain (2) as:

$$E = \int_0^\infty \frac{4\pi v^2}{c^3} \frac{hv^2}{\exp\left(\frac{hv}{kT}\right) - 1} dv \qquad (3)$$

Or as:

$$E = \int_0^\infty \frac{8\pi v^2}{c^3} \frac{\frac{1}{2}hv^2}{\exp\left(\frac{hv}{kT}\right) - 1} dv \qquad (4)$$

But

$\frac{8\pi\nu^2}{c^3}.\frac{1}{\exp\left(\frac{h\nu}{kT}\right)-1}d\nu$ is the number of oscillators per unit volume in the frequency intervalν & $\nu + d\nu$ in the three dimensional space.

Equation (2) is the density of power of the black body in $[Watt.m^{-3}]$.

What does it mean?:

Equation (3) mean that the mean power of an oscillator is:

$$W = \frac{h\nu^2}{\exp\left(\frac{h\nu}{kT}\right)-1} \qquad (5)$$

And so in a black body oven that at any time only 50% of Planck resonators radiate energy, the others (also 50%) are absorbing energy. It is logic in an equilibrium state.

Equation (4) mean that all oscillators radiate energy & the mean power of an oscillator is $\frac{\frac{1}{2}h\nu^2}{\exp\left(\frac{h\nu}{kT}\right)-1}$. We reject this description because the black body will explode by this manner and there is no equilibrium.

If we take in consideration Planck assumption that only $\eta = 1 - \exp\left(-\frac{h\nu}{kT}\right)$ oscillators radiate energy in the frequency interval ν & $\nu + d\nu$ so we should have that[2]:

$$E = \int_0^\infty \frac{8\pi\nu^2}{c^3}\frac{h\nu^2}{\exp\left(\frac{h\nu}{kT}\right)-1}\left(1-\exp\left(-\frac{h\nu}{kT}\right)\right)d\nu = \frac{4\pi k^5}{c^3h^4}T^5\zeta(5)\Gamma(5)$$

And this leads us after replacing $\frac{h\nu}{kT}$ $by\ x$ to:

$\int_0^\infty \frac{x^4.e^{-x}}{e^x-1}dx = 12\zeta(5)$which is a wrong result.

If now we consider Planck theory of heat radiation we have for the mean energy of the oscillator [3]:

$$\frac{dU}{dt} = Constant$$

But we have also that $U = \frac{h\nu}{\exp\left(\frac{h\nu}{kT}\right)-1}$ than we get:

$$\frac{dU}{dt} = \frac{d(h\nu)}{dt}.\frac{1}{\exp\left(\frac{h\nu}{kT}\right)-1} + h\nu.\frac{-\frac{\frac{d(h\nu)}{dt}}{kT}.e^{\frac{h\nu}{kT}}}{\left[\exp\left(\frac{h\nu}{kT}\right)-1\right]^2}$$

And to be conform with Planck approximation ($h\nu \ll kT$) we get:

$$\frac{dU}{dt} \approx \frac{d(h\nu)}{dt}.\frac{kT}{h\nu} + h\nu.\left(\frac{kT}{h\nu}\right)^2.\left(-\frac{\frac{d(h\nu)}{dt}}{kT}\right).\left(1+\frac{h\nu}{kT}\right) = -\frac{d(h\nu)}{dt} = -\alpha_0 \quad (6)$$

α_0 : is declared a new universal constant (but Planck don't do this declaration).

2-The fundamental law of dynamics:

Planck oscillators are classic oscillators. We can conclude from equation (5) that the power radiated by a single oscillator is:

$$\delta = h.\nu^2 \quad (7)$$

The energy absorbed by an oscillator is as a multiple integer of the quantity:

$$\varepsilon = h.\nu \quad (8)$$

This energy is as:

$$\varepsilon = \int \delta.dt \quad (9)$$

So:

$$d\varepsilon = \delta.dt$$

Than:

$$dt = \frac{d\nu}{\nu^2} \quad (10)$$

By definition the power is the force scalar the speed of the corpuscle (we suppose that motion is in a straight line):

$$W = f.v = h\nu^2$$

So the force acting on the corpuscle is:

$$f = \frac{1}{v}.h\nu^2$$

Duality of wave-corpuscle implies that:

$$\frac{1}{v} = \frac{d\tilde{k}}{d\omega}$$

with $v = v_g$: the group speed of the packet of waves assimilated as a corpuscle;

$\tilde{k}$: wave-vector of the packet of waves

$\omega = 2\pi\nu$: the frequency of the packet of waves.

So:

$$f = h\nu^2 . \frac{d\tilde{k}}{d\omega} = h\nu^2 . \frac{d\tilde{k}}{2\pi d\nu} = \hbar\nu^2 . \frac{d\tilde{k}}{d\nu} = \frac{d(\hbar\tilde{k})}{dt}$$

With : $\hbar = \frac{h}{2\pi}$: reduced Planck constant.

$\hbar k$: have the dimension of a moment. So:

$f = \frac{dp}{dt}$ with $= mv$: is the moment of the corpuscle.

This relation is generalized as:

$\boldsymbol{f} = m\boldsymbol{\gamma}$ (11)

With: $\boldsymbol{\gamma} = \frac{d\boldsymbol{v}}{dt}$the acceleration of the corpuscle

m : the mass of the corpuscle.

Equation (11) is the fundamental law of dynamics or the Newton first law.

3.The photon impact:

For a packet of waves the force is :

$$f = h\nu^2 . \frac{d\tilde{k}}{d\omega} = \frac{\hbar\omega^2}{4\pi^2} . \frac{d\tilde{k}}{d\nu} = \frac{\hbar\omega^2}{2\pi^2} . \frac{d\tilde{k}}{d\omega}$$

For a photon considered as a packet of waves we have:

$\frac{1}{c} = \frac{d\tilde{k}}{d\omega}$ because $\tilde{k} = \frac{\omega}{c}$

So the impact of a photon which hit a surface is:

$f = \frac{\hbar\omega^2}{2\pi^2 c}$ (12)

4.Universal time:

From equation (6) we can deduce that for an oscillator:

$h\nu = \alpha_0 \tau$ (13)

with: τ: a characteristic time of the oscillator &$d\tau = d\tilde{\zeta}$when the energy of the oscillator is varying;

$\tilde{\zeta}$: Universal time (the time τ is the “position” of the oscillator in the axle of the absolute time). It is like a fifth dimension of the oscillator.

Since the radiancy (2) of the black body have the dimension of $Watt.m^{-3}$ than the Universe in which the black body exist have five dimensions (Do the analogy with Kurlbaum measurements: since the radiancy have the dimension of $Watt.m^{-2}$ than the Universe in which the black body exist have three dimension).

The time t is relative .

Since we declare that the speed of light c is an universal constant than Lorentz transformations of space & time are applicable.

The Planck formulae $\varepsilon = h\nu$ holds for classic dynamics and for relativist dynamics. In relativist dynamics the relation $\hbar\widetilde{\boldsymbol{k}} = \boldsymbol{p}$holds also with $\boldsymbol{p} = \frac{m.v}{\sqrt{1-\frac{v^2}{c^2}}}$ but the relation of dynamics (11) doesn't hold because it is not invariant by Lorentz transformations. Which is invariant in relativist dynamics is the transformations of energy & moment. Energy of a corpuscle in relativist mechanics is $\varepsilon = \frac{m.c^2}{\sqrt{1-\frac{v^2}{c^2}}}$.

5.Wave-corpuscle duality:

Planck oscillator should have enough time to absorb energy from radiation . The Planck condition for this is that the frequency of the oscillator times time should be a great integer or in other manner:

$\nu.t \gg 1$ (14)

A corpuscle should be considered as a pulse and not as a packet of waves because in the model of the last one waves are reinforced an destroy each other in many regions of space-time . The model of the pulse is limited in space-time and so the pulse should not spread so much in time. This condition implies that:

$\nu.t < 1$ (15)

The condition satisfying the two models is :

$\nu.t \approx 1$ (16)

Which means that:

$dt = -\frac{d\nu}{\nu^2}$ (17)

We take always dt positive and so we can omit the sign minus in (17).

6-Generalasation of the notion of density of power:

The number of modes with frequencies between ν & $\nu + d\nu$ in a $D - volume\ V$ is :

$$N(\nu) = (D-1)V.\frac{2}{\Gamma(\frac{D}{2})}\left(\frac{\sqrt{\pi}}{c}\right)^{D} \nu^{D} d\nu \qquad (18)$$

The density of "energy" of a black body in $D - 1\ space\ dimensional$ Universe is :

$$\rho_T = \int_0^{\infty} \rho_T(\nu) d\nu \text{ with } \rho_T(\nu)d\nu = \frac{N(\nu)}{V}.\frac{h\nu}{\exp\left(\frac{h\nu}{kT}\right)-1} d\nu = (D-2).\frac{2}{\Gamma(\frac{D-1}{2})}.\left(\frac{\sqrt{\pi}}{c}\right)^{D-1} \frac{h\nu^{D}}{\exp\left(\frac{h\nu}{kT}\right)-1} d\nu \qquad (19)$$

The "radiancy" of a black body in $D - dimensional$ Universe is :

$$R_T = \frac{\Gamma(\frac{D}{2})}{\Gamma(\frac{D+1}{2})}.\frac{c}{2\sqrt{\pi}}.\rho_T = \frac{\Gamma(\frac{D}{2})}{\Gamma(\frac{D+1}{2})}.\frac{c}{2\sqrt{\pi}}.\int_0^{\infty} 2\left(\frac{\sqrt{\pi}}{c}\right)^{D}.\frac{D-1}{\Gamma(\frac{D}{2})}.\frac{h\nu^{D}}{\exp\left(\frac{h\nu}{kT}\right)-1} d\nu = \frac{1}{\Gamma(\frac{D+1}{2})}.\int_0^{\infty} 2\left(\frac{\sqrt{\pi}}{c}\right)^{D-1}.\frac{D-1}{\Gamma(\frac{D}{2})}.\frac{\nu^{D-2}h\nu^{2}}{\exp\left(\frac{h\nu}{kT}\right)-1} d\nu \qquad (20)$$

This means the density of power per unit $D - 1$ volume.

The mean power of an oscillator is $\frac{h\nu^2}{\exp\left(\frac{h\nu}{kT}\right)-1}$.

The percentage of power radiant oscillators is:

$$\eta_{D-1} = \frac{\frac{1}{\Gamma\left(\frac{D+1}{2}\right)}.(D-1)}{(D-2)\frac{2}{\Gamma(\frac{D-1}{2})}} = \frac{1}{D-2} \qquad (21)$$

References:

[1] Cardoso & de Castro "The blackbody radiation in D-dimensional Universes" arxiv 0510002v1 ,

https://arxiv.org/abs/quant-ph/0510002

[2] Max Planck "Theory of Heat Radiation" page 269, https://www.gutenberg.org/files/40030/40030-pdf.pdf

[3 Max Planck « A propos de la loi de distribution de l'énergie dans le spectre normal » Comptes Rendus 2 p202-237 (1900).

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