DOES ENERGY AND IMPULSE ARE INTER CONVERTABLE

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Abstract: Consider a photon of relativistic mass **'m'** moving with speed **'c'** is associated with the wavelength **'λ'** is given by the relation ***λ=h/mc, Where h=planck's constant (6.625*10^-34 JS).*** According to **wave theory,** speed of the photon wave is given by **c = λ /T**, where **T**= time period. By substitution of value of **'c'** in the equation **λ = h/mc,** we get the expression **m λ^2 = hT.** According to **wave theory,** as frequency of photon wave is given by **f=1/T.** [Academia Arena, 2010;2(5):15-18] (ISSN 1553-992X).

Keywords: photon; relativistic mass; wavelength; wave theory

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According to **wave theory,** speed of the photon wave is given by **c = λ /T**, where **T**= time period.

By substitution of value of **'c'** in the equation **λ = h/mc,** we get the expression **m λ^2 = hT.**

According to **wave theory,** as frequency of photon wave is given by **f=1/T.**

Then the equation **m λ^ 2 = hT** becomes **f=h/mλ^2**

De Broglie wavelength associated with the photon is given by **λ= h/p,**

thus the equation **f=h/mλ^2** becomes **f=p/mλ.**

Angular frequency associated with the photon is given by **ω= 2 πf.**

By putting the value of **f=p/mλ.** in the above equation we get **ω= 2 πp/mλ.**

The above equation **ω= 2 πp/mλ.** can be applied to both photons and material particles like electron in motion. Debroglie wavelength associated with the electron is given by **λ=h/mv**

Where v=velocity of electron in motion

Then the equation **ω= 2 πp/mλ** becomes **ω= 2 πpmv/mh** i.e **ω= 2 πpv/h.**

Part : 2

Consider a electron of mass **"m_e"** at rest, total energy associated with the electron is given by **"m_e c^2".** Suppose radiation of energy **hf** is incident on this electron at rest. Part of energy **hf"** is absorbed by electron and part of energy **hf’** is scattered by electron . Absorbed energy **hf”** is converted to motion of electron, hence electron travels a distance **‘x’** in time **‘t’.** let θ is the scattering angle.

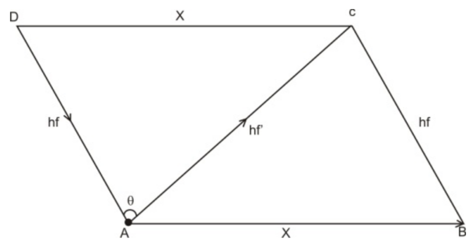

Figure :1 –schematic diagram of scattering of energy of photon by electron

x= Linear displacement of electron

hf = Energy of incident radiation

hf’ = Energy of scattered radiation

θ = scattering angle

Consider a parallelogram ABCD constructed as shown in the figure 1.

Let AB=CD=x, AD=BC=hf, AC=hf’(opposite sides in parallelogram are equal)

Law of cosine is given by **a^2=b^2+c^2-2bc cos θ.** Let a = x, b=hf, c=hf’, cos A = cosθ.

By applying the law of cosine to the triangle ADC, we get

X^2=(hf)^2+(hf’)2-2(hf)(hf’) cos θ = 1

By law of conservation of momentum of photon.

We get $\vec{p}_{y} = \vec{p}_{y''} + \vec{p}_{y'}$ where $\vec{p}_{y}, \vec{p}_{y''}, \vec{p}_{y'}$ be the momentum of incident, absorbed and scattered photon respectively.

Let us assume absorbed momentum of photon = momentem of electron

i.e. $\vec{p}_{y''} = \vec{p}$

Thus $\vec{p}_{y} = \vec{p} + \vec{p}_{y'}$ where $\vec{p}$ = momentum of electron

$\vec{p} = \vec{p}_{y} - \vec{p}_{y'}$ Squaring on the both sides we get

P^2= $\left(\vec{p}_y - \vec{p}_{y'}\right)$^2, as (a-b)^2=a^2+b^2-2ab

Thus the above equation becomes **p ^2=p_y ^2+$p_{y'}$ ^2-2** $|\vec{p}_y \cdot \vec{p}_{y'}|$

According to dot product rule | $\vec{a} \bullet \vec{b}$ **|= |a||b|cosθ**

Then we get **p^2= p_y ^2+ $p_{y'}$ ^ 2-2| p_y | | $p_{y'}$ | cos θ**

Let us multiply the above equation by **c ^ 2**we get

Where **c** = speed of light in vaccum **(3* 10 ^ 8 m/s)**

P ^2 c ^2 = p_y ^ 2c ^2 +$p_{y'}$ c^2-2| p_y | | $p_{y'}$ |c^2 cos θ

As we know frequency of photon is directly proportional to it's momentum

i.e **hf = pc** thus the below equation is obtained

p ^2 c ^ 2= =(hf)^2+(hf')2-2(hf)(hf')cos θ = 2

By comparison of 1 and 2 we get **x ^ 2 = p ^2 c^ 2**

i.e **x = pc** (position of electron is defined as the function of it's momentum)

As told earlier position of electron is defined as a function of it's momentum i.e **x = pc**

Small change in momentum of electron causes small change in it's position **i.e. dx = dpc** hence,

dp = dx/c

Newton second law of motion is mathematically represented by equation **F=dp/dt**

Where **F =** force exerted by photon

dp = Small change in momentum of electron with respect to time

As dp = dx/c then the above equation becomes **F= dx/dtc.**

as velocity of electron is defined as **v = dx/dt.**

Then **F =v/c** is obtained

Force exerted by photon is defined as function of velocity of electron

As impulse exerted by photon is mathematically given by **I = F dt.**

then the equation **F= dx/dtc** becomes **Fdt = dx/c**

i.e I =dx/c

Impulse exerted by photon is defined as function of change in position of electron
At point A and B mass of electron is m_ei.e total energy assosiated with electron is m_ec^2. (as electron is at rest at

point Aand B)
But in between point A and B mass of electron is mc^2 (since electron is in motion in between point A and B)
Hence total energy of electron in motion is mathematically given by **$E= m_ec^2+hf'$**
(As absorbed energy adds up to rest mass energy) where E= total energy of electron in motion
hf'=absorbed energy of photon
m_ec^2=rest mass energy of electron
As absorbed momentum of photon equals the momentum of electron i.e **$p_{y''}= p$**
As **x=pc** (position of electron is defined as the function of it's momentum) then $x= p_{y'}c$
$p_{y'}c=hf'$then **x=hf'** then the equation **$E= m_ec^2+hf'$** becomes equation **$E= m_ec^2+x=3$**
According to Einstein equation **$E= m_ec^2+E_k=4$**
By camparison of 3and 4 we get **$E_k = x$** i.e kinetic energy of electron = position of electron
Small change in kinetic energy of electron causes small change in it's position i.e **$d E_k = dx$** i.e **I =dx/c**
i.e **$I= d E_k/c$** i.e **$d E_k=Ic$**
According to **<u>workenergy theorm</u>**
Work done on particle equals change in kinetic energyof particle **i.e $W= d E_k$** i.e **W= Ic**
Work done on particle involves storage of energy in particle i.e **$W=E_a$** where E_a= Energystored in particle.
E_a =Ic ,energy stored in particle is defined as a function of impulse applied
Thus $E_a \; a \; I$ (as c is constant) i.e impulse and energy are interconvertable.

2) <u>Proof for Einstein predicted formula</u> E=tc

As **x = pc** (position of electron is defined as the function of it's momentum)

As momentum of electron can be given by **p=mv** then the equation **x = pc** becomes **x=mvc i.e x/v=mc**
According to newton **v=x/t i.**e equation **x/v=mc** becomes **t=mc**
According to Einstein **E=mc^2** hence **E=mcc** becomes **E=tc**

1/20/2010