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Experimentally Proved that, The Refractive Index Effected on Energy of Photon in Medium

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Abstract In this study we proved experimentally that, the refractive index effected on energy of photon in medium. Also we have shown that, the model of photon as mass particle associated with wave is correct [3, 4], by analysis the energy of photon measured experimentally, with principles of new theory.

Keywords Photon, Mass, Energy, Particle, Wave

1. Introduction

Photons exhibit wave-particle duality meaning that photons acts in a manner consistent with wave or particle in different situations [1]. Yong's experiment is still considered to be the most convincing proof of the wave nature of light, Feynman put forward his view that when an object behaves like a wave, it should produce interference fringes in Yong's double slit experiment, and when behaves like a particle, it will produce no fringes in the same experiment [2].

We demonstrated in our articles [3, 4], theoretical model of photon as mass particle associated with wave. In this study we try to confirm this model experimentally.

2. Experimental

A simple system was used to measure the kinetic energy of photon in medium, first we measured the (energy / second) of photons in air by using, laser beam (He = Ne, λ = 632.8μm) then we used a cell contain a water vapor, the laser beam incident perpendicular on the window of the cell transmitted (97%) from the incident light. The (energy /second) of photons was measured inside the cell, finally we measured the (energy/second) of photons outside of cell.

The results in the following table (1)

Table 1. Experimental results

(E/s) in Air	(E/s) inside cell	(E /s)outside cell
4.71 mJ/s	4.37 mJ/s	4.13 mJ/s

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The difference in the laser energy in air and medium is due to the absorbance, scattering, and as we think to velocity of photon. To estimated the effect of velocity on energy we shall made analysis of the parameters in table (1).

3. Simple Analysis

The laser beam incident on second window of the cell by an angle because of refraction, then (4%) from the energy will reflected from the first surface of window and (4%) from the second surface,

$$4.37*0.04=0.1748\text{mJ/s}$$
$$4.37-17.48=4.1952\text{mJ/s}$$
$$4.1952*0.04=0.1678\text{ mJ/s}$$

The total losses for reflection is

$$0.1748+0.1678=0.3426\text{ mJ/s}$$

According to this simple simulation, the outside energy must be:

$$4.37-0.3426=4.0274\text{mJ/s}$$

But we measured the energy outside as in table (1) 4.13 mJ

$$4.13-4.0274=0.1026\text{mJ/s}$$

This difference came from effect of velocity, it means that the kinetic energy of photon inside cell will decrease 0.1026mJ/s, because its velocity (v).

The laser beam incident perpendicular on the window of the cell which transmitted (97%) from the incident light, so the energy of photon in medium when the photon pass throw window is:

$$4.71-4.71*0.03=4.5687\text{ mJ/s}$$

If the cell transmitted 100% of incident light, then the decrease in energy of photon in medium is:

4.71*0.1026/4.5687=0.1057731959=0.106 mJ/s

The kinetic energy of photon in medium is:

4.71-0.106 = 4.604mJ/s

The refractive index of medium (n), can be calculate [3,4],

$$n=E_{vacuum}/E_{k\ medium} \quad (1)$$

$n=4.71*10^{-3}/4.604*10^{-3}$

$n=1.023023458$

We summarized the analysis of experimental results in table (2),

Table 2. Experiment results

Laser beam energy in air(E mJ/s)	Energy loss by velocity (E_vmJ/s)	Kinetic energy in medium with velocity loss (E_kmJ/s)	Refractive index
4.71	0.106	4.604	1.023023458

The difference between (E) in air and in medium is due to the velocity of photon.

4. Number of Photons

To be sure that this result is correct, the number of photons in air and medium must be the same. The number of photons can be calculated according to this relation;

no.ph= total energy / energy of one photon (2)

or

no.ph=total natural mass/natural mass of one photon

4.1. In Vacuum

As in the current theories, the energy of photon

$$E = hc/\lambda \quad (3)$$

$E = 6.626*10^{-34}*3*10^{8}/632.8*10^{-9}$

$E = 0.03141276856*10^{-17}$ J

We can find the natural mass of one photon from the relation;

$$m_{nat} = E/c^2 \quad (4)$$

$m_{nat}=0.03141276856*10^{-17}/9*10^{16}$

$=0.003490307628*10^{-33}$ Kg

Total natural mass for laser beam from equation (4):

$m_{tot}=4.71*10^{-3}/9*10^{16}=52.33333333*10^{-19}$Kg

According to equation (2), the number of photons in case of energy and natural mass;

no.ph for energy = $4.71*10^{-3}/0.03141276856*10^{-17}$

= $1499390281*10^{9}$ photon/s

no.ph for natural mass

= $52.33333333*10^{-19}/0.003490307628 * 10^{-33}$

= $1499390281*10^{9}$photon/s

it is clear that, the number of photons are the same in case of energy or natural mass.

4.2. In Medium

If we want to find the energy, and relative mass of photon in medium, the current theories assumed that, there is no effect of refractive index on the energy and stay constant while the photon is mass less.

According to new theory, the energy is effected by the medium and decrease according to refractive index, while the photon has natural mass in air and effective mass in medium which depend on refractive index.

We can calculate the kinetic energy in medium as [3, 4]:

$$E_k=h \square / n$$

Where $\square=c/\lambda$, $n=c/v$, then:

$$E_k=hv / \lambda \quad (5)$$

$V=c/n=3*10^{8}/1.023023458=2.932484076*10^{8}$ m/s

$E_k= 6.626*10^{-34}*2.932484076*10^{8}/632.8 *10^{-9}$

$= 0.03070581462*10^{-17}$J

To calculate the effective mass of one photon in medium [3, 4]

$$E_k=m_{rel}v^2 \quad (6)$$

$0.03070581462*10^{-17} = m_{rel}*(2.932484076*10^{8})^2$

$m_{rel} = 0.0035707666579*10^{-33}$ Kg

The total kinetic energy in medium:

E_k = no.ph*Energy of one photon

$E_k = 1499390281*10^{9}*0.03070581462*10^{-17}$

$= 4.604000001$ mJ/s

This result is very close to the analysis result of experiment (E_k=4.604mJ/s) as in table (2).

The very small difference between two results is due to the accuracy of detector.

Total relative mass in medium from equation (6):

$4.604*10^{-3}/(2.9326484076*10^{8})^2=53.53822764*10^{-19}$Kg

According to equation (2) for energy and natural mass in medium;

no.phfor energy = $4.604*10^{-3} /0.030706581462*10^{-17}$

= $1499390281*10^{9}$photon/s,

no.phfor natural mass

= $53.53822764*10^{-19}/0.003570666579*10^{-33}$

= $1499390281*10^{9}$photon/s

it is clear that, the number of photons are the same in case of kinetic energy or effective mass of photon in medium and it is the same as in vacuum.

The relation between natural mass and effective mass is refractive index as [3, 4],

$$n=m_{rel}/m_{nat} \quad (7)$$

$n=0.003570666579*10^{-33}/003490307628*10^{-33}$

$=1.023023458$

The result in equation (7), for refractive index is the same as in table (2).

From all the results the number of photons are constant, which indicate that all calculations are correct.

5. Calculate of Wavelength

To calculate the wavelength of photon in medium, as in current theory;

$$\lambda=\lambda_o/n \quad (8)$$

$\lambda=632.8*10^{-9}/1.023023458=618.558*10^{-9}$ m

while in new theory (1,2)

$$\lambda=h/m_{rel}v \quad (9)$$

$\lambda=6.626*10^{-34}/ 2.932484076*10^{8}* 0.003570666579*10^{-33}$
$\lambda=632.8*10^{-9}$m

6. Refractive Angle

6.1. Current Theory

To found the refractive angle of the laser beam according to senll's law,

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \quad (10)$$

As in the experiment the incident angle is (90^0);

$1=1.023023458 \sin\theta_2$
$\sin\theta_2 = 0.977494692$
$\theta_2=1.358239355^0$

6.2. New Theory

The dispersion phenomena in new theory explained according to natural mass of photon [3, 4]

$$m_{nat} \sin\theta_1 = m_{rel} \sin\theta_2 \quad (11)$$

$52.33333333*10^{-19} = 53.53822764*10^{-19}\sin\theta_2$
$\sin\theta_2=52.33333333*10^{-19}/53.53822764*10^{-19}$
$\sin\theta_2=0.977494691$
$\theta_2=1.35823935^0$

Which is the same result from equations (10,11).

7. Momentum of Photon in Medium

7.1. Current Theory

If the photon is wave as in The Minkowski version [5]

$$P=nE/c \quad (12)$$

$P = 1.023023458*0.03141276865*10^{-17}/3*10^{8}$
$P = .0.01071199997*10^{-25}$J.s/m

If the photon is particle as in Abraham version [6]

$$P=E/nc \quad (13)$$

$P = 0.03145069532*10^{-17}/1.023023458*3*10^{8}$
$P = 0.01023527155*10^{-25}$ J.s/m

The parameter (E) in equation (12) represent the energy in medium, which is constant in vacuum or medium.

7.2. New Theory

In new theory the momentum in medium is [3,4]

$$P=E/c \quad (14)$$

$P=0.03141276865*10^{-17}/3*10^{8}$
$P=0.01047092288* 10^{-25}$ J.s/m

Equation (14) represent the momentum of photon in medium, which h the same equations as in vacuum, this means that the controversy of Minkowisky and Abraham is solved.

We can summarized the analytical results in table (3).

8. Conclusions

In the current theories as we know that the energy of photon is constant in medium or vacuum, while the momentum is changeable according to Minkowisky and Abraham. In this study we proved that the energy of photon is decreased in medium because of the refractive index of medium and the momentum is constant.

The important factor in this study which indicate that the results are correct is the number of photons which is the same number in all analytical steps.

In summary, by analysis of the energy of photon measured experimentally, with principle of new theory, we have shown that, the model of photon as mass particle associated with wave [3, 4] is correct. As shown in table (3); the energy is changeable with refractive index, and the photon explained as particle has natural, and relative mass. The wavelength and momentum in medium are constant, while the dispersion phenomena was explained with mass of photon.

Table 3. Analytical results

	Current theory		New theory	
	Vacuum	Medium	Vacuum	Medium
E 10^{-17} J	0.031413276865	0.03141276865	0.03141276865	0.03070581462
m 10^{-33} Kg	0/0	0	0.003490307628	0.003570666579
No.ph photon/s	$14979390281*10^9$	$1499390281*10^9$	$1499390281*10^9$	$1499390281*10^9$
P 10^{-25} J.s/m	0.01047092288	1-0.01071199997 2-0.01023527155	0.01047092288	0.01047092288
λ m	$632.8*10^{-9}$	$618.558*10^{-9}$	$632.8*10^{-9}$	$632.8*10^{-9}$
Angle of refraction	/	1.358239355^0	/	1.35823935^0

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