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Effect of Refractive Index on Photon Natural Mass and Wavelength

Asmaa J. Kadhim Al- Kinani *Adnan Salih Al-Ithawi* *Issa M. Kadhim*[*]

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Abstract:

In this article it is proved experimentally that the photon is a particle that has mass and constant wavelength by explaining the effect of refractive index on the wavelength and the natural mass of photon. It is very difficult to measure the mass of photon, a simple and easy process was proposed in this paper to calculate the mass length of photon in vacuum (Y) and in medium (Y*), by measuring the length of laser beam in air (L_{air}) and in medium (L_{med}). A new method was postulated to calculate refractive index by using these relations ($n = Y^*/Y$), and ($n = L_{med} / L_{air}$) which supposed a new theory of light.

Key words: Photon energy, Photon mass, Refractive index, Wavelength of photon.

Introduction:

Until now both previous light theories could not explain light behavior. Our previous work suggested a new explanation for the nature of light. It was assumed that photon has a natural mass which expresses a certain wavelength. And a set of new relations was derived (1, 2).

$m_{eff} = n\, m_{nat}$ … 1

$E_k = h\nu/n$, or $E_k = n\, m_{nat}\, v^2$ …2

$\lambda_o = h / m_{nat}\, c$ …3

Where (m_{nat}, m_{eff}) is the mass of photon in vacuum and medium respectively, (n) refractive index, (E_k) energy of photon in medium, (λ_o) wavelength of photon in air, (ν) frequency, (h) Plank constant, and (c, v) the velocity of light in vacuum and medium respectively. Index of refraction (n) has a large number of applications and can be measured by refractometer systems, which depend on Snell's law and all these systems depend on the wave theory of light (3, 4).

(n) is defined as the ratio between the velocity of light in vacuum to the phase velocity (v_p) of light in a medium (5). So when light passes through medium, the wavelength of light in medium is decreased by a factor of refractive index;

$\lambda = \lambda_o / n$ …4

Where (λ) is the wavelength in medium. When laser beam with wavelength 532 nm passes through water with refractive index 1.33 then λ will be 400 nm and leading to an increase in energy as the frequency of photon of wavelength 400 nm is greater than that of 532 nm.

But according to the current theory of light, the energy is constant because frequency is constant in medium and vacuum.

On the other hand, experimentally measured energy is decreased by factor of refractive index as clearly seen in eq.2 (6). By using refractive index, light wavelength was calculated (1, 2) and compared with our previous explanations to conclude that photon is particle that has a mass and constant wavelength. Simple experiments were implemented depending on eq. 4.

Materials and Methods:

Continuous laser (CW) beam 532 nm, tank of glass, detector, oscilloscope, chopper, and water with refractive index 1.3337 are used in this experiment. In the first part of experiment a CW laser beam 532 nm was chopped by using chopper then the signal recorded on oscilloscope via a detector placed in empty tank of glass, as shown in Fig.1.

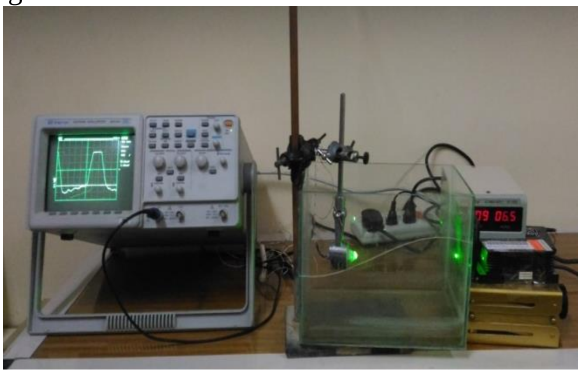

Figure 1. Setup for laser 532 nm in empty tank, the length of beam as clearly seen on oscilloscope is approximately 0.9 cm

[*]Department of Physics, College of Science for Women, University of Baghdad, Baghdad, Iraq.
[*]Corresponding author: asmaajk_phys@csw.uobaghdad.edu.iq

The length of laser beam (L_{air}) was measured as a distance from the beginning of the signal to the end at it's the bottom, and it is approximately 0.9 cm. Now the number of wavelengths ($no._w$) is ($no._w = L_{air} / \lambda_o$)

$no._w = 0.9*10^{-2} / 532*10^{-9} = 1692$ wavelengths.

When this beam passes through water with N = 1.3337, and according to eq. 4 is λ = 398.9 nm, the length of laser beam in medium (L_{med}) is the number of photons ($no._w$) multiplied by λ.

$L_{med} = 0.675$ cm

This means that the length of laser beam decreases in medium.

In the second part of experiment, a tank of glass was filled with water of n = 1.3337 and used as previously mentioned (7). A detector was immersed in water. The signal of chopped laser beam that passes through water and incident on the detector is recorded on the oscilloscope as shown in Fig. 2.

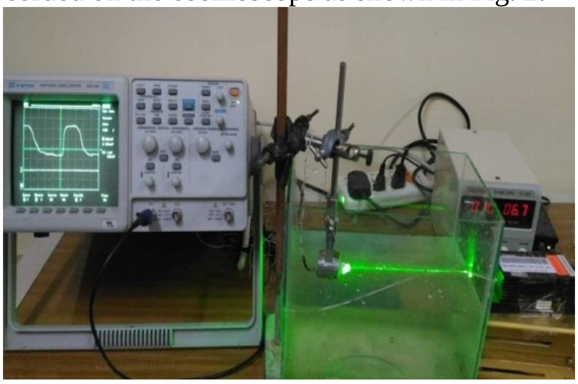

Figure 2. Setup for laser 532 nm in water, the length of beam as seen on oscilloscope is approximately 1.2 cm

From Figs. 1, 2, it is apparently shown that the pulse is expanded in length and lowered in amplitude and subsequently energy is supposed to be reduced (energy proportional with amplitude). With respect to the length laser beam (L_{med}), it is approximately equal to 1.2 cm and depending on eq.4, it should be decreased by a factor of N, however, it is experimentally proved to be increased by the same factor;

$n = L_{med} / L_{air}$ …5

n =1.2 /0.9 = 1.3333333.

This gives rise that the wavelength increases by factor of refractive index,

$\lambda = n\,\lambda_o$ … 6

Obviously, there is contradiction between the experimentally extracted eq.6 with the previously certified relationship (eq.4).

Consequently, another experiment was performed which depends on deflection of light as it is incident on prism. Due to the phenomenon of dispersion, when white light is transmitted through a prism, it is dispersed to different colors with different angles. Each color has its own angle.

Two types of laser 532 nm, and 405 nm are applied, tank of plastic, prism, water and Protractor. These lights of lasers pass through the empty tank and incident on protractor with an angle of 90^0 as shown in Fig.3.

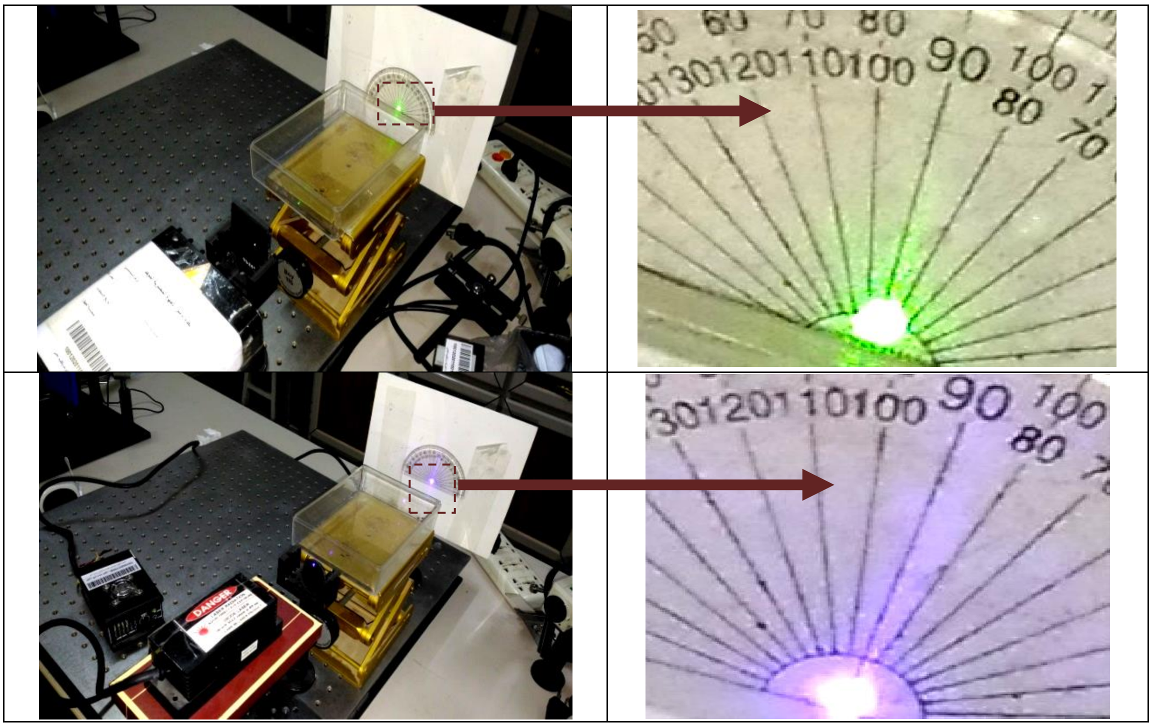

Figure 3. Setup of above: laser 532 nm, and below: laser 405 nm, both pass through an empty tank and incident on protractor as shown in the magnified scale on right of each image.

When these lasers transmit through prism in an empty tank with the same angle, they are deflected with different angles as seen in Fig.4.

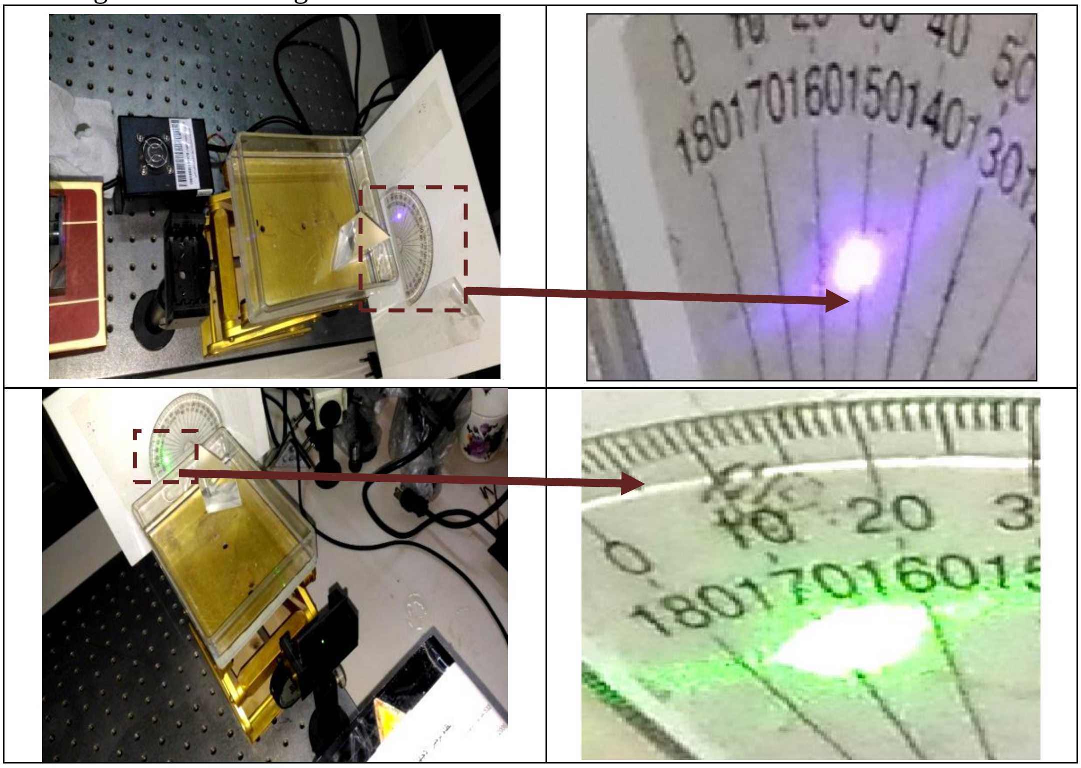

Figure 4. Setup of above: laser 532 nm, below laser 405 nm, both are incident on prism in empty tank, the deflection angles on protractor are seen in the magnified scale on right of each image.

In the second step the tank containing prism was filled with water and the lasers pass through both water and prism. Depending on eq.4, the wavelength of these lasers are changed and proportionately reduced relative to refractive index i.e. 532 nm will be 400 nm, so the deflection angle of 532 nm in water will be equal to the deflection angle of 400 nm in air. Meanwhile, with eq.6, the wavelength of these lasers will be changed and proportionately increased with refractive index i.e. 400 nm will be 532 nm. In conclusion, the deflection angle of 400 nm in water should be equal to the deflection angle of 532 nm in air.

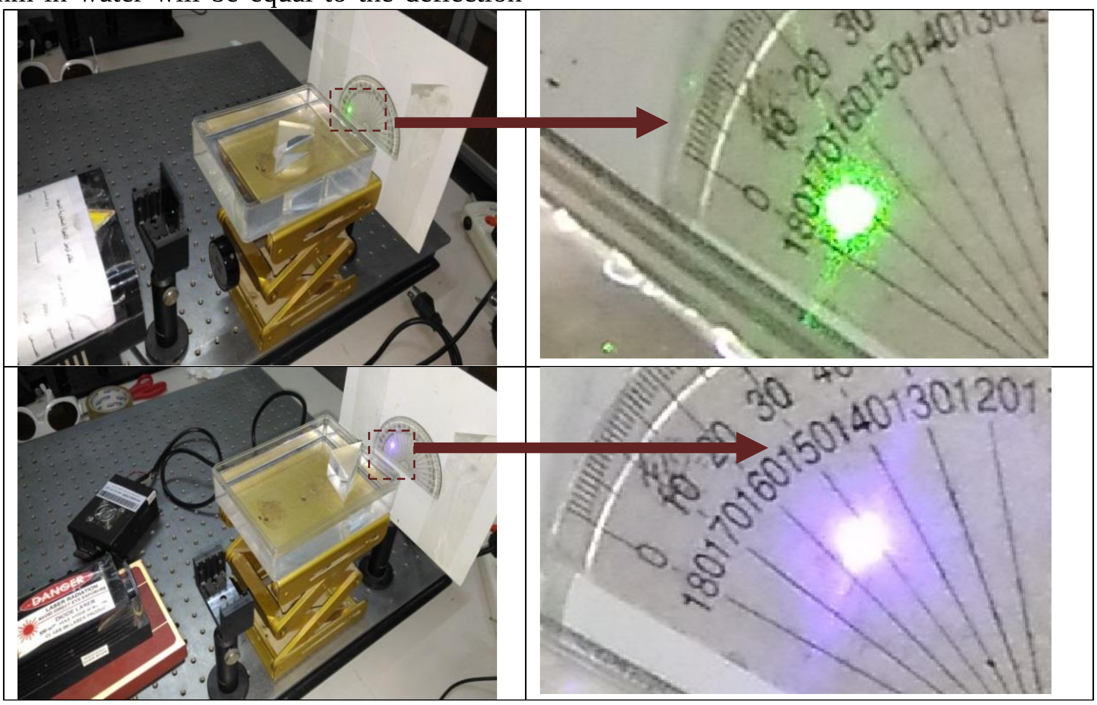

Figure 5. setup of a: laser 532 nm, b: laser 400 nm, both are incident on a prism in a tank filled with water, the deflection angles on protractor as shown in magnified scale.

However, the recoded results in Fig. 5 showed that:

The deflection angles of 532 nm, and 400 nm do not change after filling the tank with water as in Fig 4 apart from small difference in deflection because of the diffraction of laser in water, which proves that the wavelength is still constant.

$\lambda = \lambda_o$. …7

So all these arguments may indicate that eq.s 4, 6 and 7 are all correct.

Discussion:

It can be argued that the refractive index affects another parameter of photon which is natural mass (m_{nat}). The wave theory cannot explain this situation, as well as particle theory because they depend on assumption that the photon is massless.

This may be better explained depending on the principle of assumption which suggest that the wavelength of photon is constant: (1,2).

$\lambda_o = h / m_{nat}\, c$ … 3

$h / c = m_{nat}\, \lambda_o$ …8

Meanwhile it was supposed that (1):

$Y = m_{nat}\, \lambda_o$ …9

Subsequently, by substitution from eq. 8 to eq. 9 the resulted equation will be:

$Y = h / c$ …10

This means that the mass length of photon Y is constant for different types of photons in air;

$Y = 6.62607004 * 10^{-34} / 3*10^{8} = 2.208690013 * 10^{-42}$ Kg. m.

And for laser beam 532 nm, will be;

$m_{nat} = 4.15 * 10^{-36}$ kg

Going back to the first setup with laser beam 532 nm that has number of wavelengths equal to 1692, The length of this beam in air is

$L_{air} = Y * (no._{w}) / m_{nat}$ … 11

$L_{air} = 2.208690013 * 10^{-42} * 1692 / 4.15 * 10^{-36}$

$L_{air} = 0.9$ cm

This result matches that of the first part of this work. As assumed before, there is another parameter of photon that can be named effective mass (m_{eff}) in medium (1,2) as seen in eq.1

If laser beam pass through water with refractive index 1.3337, then:

$m_{eff} = 5.534855*10^{-36}$ kg

and the mass length of photon (Y*) in medium as extracted from eq.s 1,9 is:

$Y^* = m_{eff}.\ \lambda$ …12

When eq.10 is implemented, the mass length of photon in vacuum is constant for all types of photons, but the mass length in medium is changeable parameter because it depends on mass and wavelength as in eq. 12.

Assuming the mass length depends only on the change in wavelength then eq. 4 will reveal that the wavelength decreases by refractive index λ =398.9 nm meanwhile the wavelength increases by refractive index λ =709.5 nm as in eq.6 so that the effective mass stays constant ($m_{eff} = 5.534855*10^{-36}$ kg for 532 nm).

From eq. 12;

$Y^* = 2.2078536595*10^{-45}$ kg.m for λ = 398.9 nm

$Y^* = 3.9269796225*10^{-45}$ kg.m for λ = 709.5 nm

And (L_{med}) will be:

$L_{med} = (Y^*/Y) * L_{air}$ …13

L_{med} = 0.899 cm for λ = 398.9 nm

L_{med} = 1.6 cm for λ = 709.5 nm

As seen experimentally in Fig2, the measured (L_{med}) is equal to 1.2 cm

With respect to eq.s 1,12,13;

L_{med} = 1.2002 cm for λ = 398.9 nm

L_{med} = 1.1975 cm for λ = 709.5 nm

These results correspond to that of the first part of this work and denote that the photon mass is changeable.

Using dispersion technique, it was demonstrated that the wavelength is constant so it can be said that the refractive index affects the natural mass (mass changeable).

From eq.s 1,12, and 13, when this laser beams with length 0.9 mm passes through water (n = 1.3337 at 25 C^{o}) (7) and (L_{med}) is:

L_{med} = 1.1998 cm

This is almost the same as in Fig.2 L_{med} = 1.2 cm and this goes with first and second parts of present work.

From the whole process, it can be said that the refractive index is:

$n = L_{med} / L_{air}$ …5

Theoretically, eq.5 is acceptable when the wavelengths (λ, λo) in eq.s 9, 12 are equal to each other as suggested by our assumption and it is experimentally confirmed as shown in Figs. 3-5.

At last but not least, it can be concluded that:

$n = Y^*/Y$ …14

And documented that the photon has natural mass and constant wavelength, as proposed by our previous work.

Conclusion:

This work supports our previous assumption that photon has a mass called natural mass in vacuum and effective mass in medium and related to each other. This character is variable and the refractive index plays the role of coefficient in this relationship. Wavelength of photon was found to remain constant when passing from one medium to another.

Refractive index of material can be calculated in a simple method by measuring the length of laser beam in vacuum and medium and applied in this relationship $n = L_{med} / L_{air}$ or $n = Y^*/Y$.

Conflicts of Interest: None.

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تأثير معامل الانكسار على كتلة الفوتون الطبيعية وطول موجته

أسماء جواد كاظم الكناني **عدنان صالح العيثاوي** **عيسى محمد كاظم**

قسم الفيزياء، كلية العلوم للبنات، جامعه بغداد، بغداد ، العراق.

الخلاصة:

في هذا البحث أثبتنا عمليا ان الفوتون هو جسيم له كتلة طبيعية وطول موجة ثابت من خلال مناقشة تأثير معامل الانكسار على طول موجته وكتلته الطبيعية. من الصعب جدا قياس كتلة الفوتون ، لذلك افترضنا في هذا البحث طريقة بسيطة وسهلة لحساب الطول الكتلي للفوتون في الفراغ وفي الوسط من خلال قياس طول حزمة الليزر في الهواء وفي الوسط. وجدنا طريقة جديدة لحساب معامل الانكسار باستخدام العلاقات بقسمة طول الليزر في الوسط على طوله في الهواء أو قسمة الطول الكتلي للفوتون في الوسط على طوله في الهواء والتي تثبت صحة النظرية الجديدة للضوء.

الكلمات المفتاحية: طاقة الفوتون ، كتلة الفوتون ، معامل الانكسار، الطول الموجي للفوتون.