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Refractive index of denser medium by assuming the speed of photon between two consecutive absorption or emission is $3 \times 10^8 \frac{m}{s}$ or 'c'

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Abstract

According to Waves optics, the velocity of light remain constant inside denser medium, if the Frequency increases then its wavelength decreases, there by adjusting its velocity. Also, refractive index of medium depends on wavelength of light, for red color refractive index is less than that of violet color, as per Cauchy's formula. So the speed of red color is more than violet in denser medium. But this is not true; the speed of all colors remains same (c) inside the crystal between two lattice points. When light enters the denser medium, the photons are being absorbed & emitted continuously. The speed of photon between two consecutive absorption or emission is $3 \times 10^8 \frac{m}{s}$, but due to difference in number of absorption and emission of various colors (photons) by atoms, they spent different times inside the crystal. Since massive photon suffers more absorption and emission. Due to this they spent more time inside the transparent medium. If we consider particle nature of light and consider photon as a particle of light, velocity of photon does not remain constant at all the point inside the crystal. Between two lattice points the velocity of photon is greater than $v = 2 \times 10^8 \frac{m}{s}$ for glass medium and at the lattice point during absorption and emission, it is less than $v = 2 \times 10^8 \frac{m}{s}$. The average velocity, not constant velocity of photon in the glass is $v = 2 \times 10^8 \frac{m}{s}$. So the expression for refractive index for photon will be $\mu = \frac{c}{l} t$,where 'l' is total length path of denser medium and 't' is the total time taken to cover the length 'l'. So the change in velocity is not due to change in wavelength of photon.

Keywords: - Frequency; deviation; emission; absorption; wavelength.

1. Introduction

Refractive Index

Absolute refractive index of a medium is defined as the ratio of speed of light in vacuum to the speed of light in medium i.e.

$$\mu = \frac{c}{v}$$

The speed of light in vacuum or air is c = $3\times10^{8} ms^{-1}$

Relative refractive index: If medium 1 has refractive index μ_1 and medium 2 has refractive index μ_2, then $\frac{\mu_2}{\mu_1} = \frac{v_1}{v_2}$ = refractive index of medium 2 relative to medium 1.

A medium having higher value of refractive index is called optically denser medium while a medium having lower value of refractive index is called optically rarer medium.

The separation of different colors present in white light is because of different deviations suffered by them, when they pass through a prism because refractive index of a medium is different for different colors. According to wave optics $\mu = \frac{c}{v}$, and μ_v is greater than μ_r, so the velocity of red light is more than velocity of violet light, so the cause of dispersion is change in velocity of different colors in dispersive medium.

According to Cauchy's formula, $\mu = A + \frac{B}{\lambda^2} + \ldots$.. Where A, B are constants and λ is the wavelength of light. This relation shows that the refractive index of material or medium depends upon wavelength or color of the light incident on it.

The wavelength of different colors is different. Red color has maximum wavelength and violet color has minimum wavelength i.e. $\lambda_r$is greater than λ_v. Therefore, Refractive index for red color is less than that of violet color. So the speed of red color is more than violet in denser medium.

Now deviation produced by small angled prism is given by

$$\delta = (\mu - 1) A$$

$$\delta_r = (\mu_r - 1) A$$

$$\delta_v = (\mu_v - 1) A$$

Hence δ_r is less than δ_v. This shows that the red color deviates least and violet color deviates the most. Thus, violet color is seen at the bottom and the red color is seen at the top of the spectrum of white light. The other colors suffer deviation in between the red and violet color.

1.1 Angular Dispersion

It is defined as the difference in the deviations suffered by the two extreme colors in passing through the prism. It is denoted by θ and is given by,

$$\theta = \delta_v - \delta_r$$

The deviation produced by small angled prism is given by

$$\delta = (\mu - 1) A$$

For red color, $\mu = \mu_r$

So $\delta_r = (\mu_r - 1) A$

For violet color, $\mu = \mu_v$

So $\delta_v = (\mu_r - 1) A$

Putting the values of δ_r and δ_v in equation 1, we get

$$\theta = (\mu_v - 1) A - (\mu_r - 1) A$$

$$\theta = (\mu_v - \mu_r) A$$

This is the expression for Angular Dispersion.

2. Objective:-

(a) First objective is to show that velocity of light is not constant in the denser medium.

(b) Second aim is to show that Refractive index of medium depends on length and time taken by photon to cross the denser medium.

3. According to wave theory:-

A) When light travel from rarer to denser medium, its speed decreases due to decrease in wavelength but its frequency and hence energy remains same.

B) Velocity of wave in a particular medium remains constant. If the Frequency increases then its wavelength decrease, there by adjusting its velocity.

But the above points are not correct. Let us check:

Ultraviolet catastrophe

An example that is currently of great interest is the way the ozone layer protects us from the dangerous short wavelength ultraviolet part of suns spectrum. In the classical description i.e. light as a wave, when a wave passed into and back out of a medium, its frequency is unchanged and although its wavelength is altered while it is in the medium, it returns to its original value when the wave emerges. Luckily for us this is not at all what ultraviolet does when it passes through ozone layer or the layer would offer any protection at all. Wave theory fails to explain, how ozone layer protect us from dangerous ultraviolet radiation.

If light is really a wave then its velocity in a medium remain same which is equal to $v = \frac{c}{\mu}$

Since for glass μ = 1.5, so $v = \frac{3\times10^8}{1.5} = 2 \times 10^8 \frac{m}{s}$.

So speed of light inside glass is $2 \times 10^8 \frac{m}{s}$.

According to wave optics when light goes from rarer to denser medium, the velocity of light changes due to change in wavelength but frequency & energy remain same. On applying de- Broglie hypothesis $\lambda = \frac{h}{mc}$, we have to say that this decrease in wavelength is due to increase in velocity, as on increasing mass, energy and frequency will increase, which is not possible according to wave optics. So the explanation of decrease in wavelength is only due to increase in velocity of photon, but velocity of photon should not be greater than c because this will contradicts Special theory of relativity as well as Foucault's experiment. So decrease in velocity is not due to decrease in wavelength as per de- Broglie hypothesis and Quantum Mechanics.

4. Refractive Index on the basis of photon theory:-

According to wave optics, the refractive index of a medium is given by

$$\mu = \frac{c}{v}$$

Where 'v' is the constant velocity of light in denser medium.

If we consider glass medium, then according to wave optics, the constant velocity of light inside glass is, $v = 2 \times 10^8 \frac{m}{s}$.

But if we consider particle nature of light and consider photon as a particle of light, velocity of photon does not remain constant at all the point inside the crystal. Between two lattice points the velocity of photon is greater than $v = 2 \times 10^8 \frac{m}{s}$ and at the lattice point during absorption and emission, it is less than $v = 2 \times 10^8 \frac{m}{s}$. The average velocity, not constant velocity of photon in the glass is $v = 2 \times 10^8 \frac{m}{s}$.

So the expression for refractive index for photon will be

$$\mu = \frac{c}{l}t$$

Where 'l' is total length path of denser medium and't' is the total time taken to cover the length 'l'.
So the change in velocity is not due to change in wavelength of photon. So wave theory, whether it is Classical or de- Broglie's fails to explains the cause of average velocity of photon inside denser medium, as well as, why photon take longer time to pass through denser medium, since its velocity inside it is c.

5. Conclusion:-

From this work, we can write the new formula of Refractive index of the medium, $\mu = \frac{c}{l}t$, where t is the time taken by photon to cross the denser medium and l is the length of denser medium. The previous formula of refractive index is talking about constant velocity of light in denser medium, which is 'v'. Also 'v' is not the constant velocity of light in the medium; it is the average velocity of light in the medium.

6. Scope: -

(1) This work helps us to understand the particle nature of light.

(2) This work helps us to understand that, refractive index of transparent medium not only depends on nature of material medium but also on length and time taken by particle to cross the denser medium.

(3) This work will help the physicists to understand the refractive index of transparent medium.

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