On the harmonic compression of light wave

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Abstract. In this paper, by taking consideration of some assumptions, the mechanism behind dual nature of light is proposed. After great wave-particle struggle physics is now reached to the fact that, light shows dual nature and in order to give possible reason behind dual nature of light I have taken little bit help from the classical mechanics. During explanation of the mechanism behind dual nature of light I have also discussed about the photoelectric effect and double slit experiment.

Keywords. Monochromatic light; compression; photoelectric effect; double slit experiment.

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1. Introduction

Sometimes light behaves like a wave and sometimes it behaves like a particle which depends on the experiment. Phenomenon such as interference, diffraction and polarization etc. can be explained on the basis of wave nature of light and phenomenon such as photoelectric effect, Compton effect etc. can be explained on the basis of particle nature of the light. For giving explanation behind dual nature of light we have to make some assumptions and assumptions are; light wave behaves like a spring. Like spring light wave can be compressed when it incident on the particle and light wave has a force constant as like spring. Though this assumptions have little bit classical touch, this assumptions will provide better understanding for dual nature of light. The paper is organized as follows. Section 2, gives a brief explanation for the dual nature of light and § 3, gives conclusions of this study and discussion on the photoelectric effect and on double slit experiment.

2. Compression mechanism for explaining dual nature of light

In order to visualize and understand the proposed mechanism we have to consider following scenario. Consider a single monochromatic light wave having wavelength λ travelling in a straight line through vacuum. If this wave incident on the particle (assume that this particle is fixed on its position in vacuum) then wave and particle will interact in two steps. In 1st step, during interaction between wave and particle; wave will give some amount of its energy to the particle however 2nd step is based on one of the most crucial assumption because by taking consideration of this assumption we can imagine how does light change its wave nature to the particle nature?. In 2nd step after giving some energy to the particle the wave begins to compress at a point of contact between wave and the particle when compression of wave stop; then this compressed part of the wave resembles like a particle and which is easy to imagine. We can understand this explanation in terms of principle of conservation of total energy. Since energy of monochromatic light wave is given by [1]

$$E_L = \frac{hc}{\lambda} \qquad (1)$$

Where λ is wavelength of given monochromatic light wave, h is a Planck's constant and c is a speed of light in vacuum. After compression the energy of monochromatic light wave will convert into the energy of compressed part of same monochromatic light wave. If we treat compressed part of monochromatic light wave as a compressed spring then the energy of compressed part of monochromatic light wave can be written as [2]

$$E_C = \frac{1}{2}kx^2 \tag{2}$$

Where k can be treated as a force constant of given monochromatic light wave and x is a difference between wavelength of given monochromatic light wave after compression and wavelength of same monochromatic light wave before compression times the total number of wavelengths which are undergoing compression. If λ is a wavelength of given monochromatic light wave before compression and λ_0 is a wavelength of same monochromatic light wave after compression then x is given as

$$x = -(n\lambda_0 - n\lambda) = -n(\lambda_0 - \lambda) = -n.\Delta\lambda \tag{3}$$

Where n is total number of wavelengths which are undergoing compression and $\Delta\lambda$ is change in the wavelength. In eq. (3) x is negative because $\lambda_0 < \lambda$. From the principle of conservation of total energy and from eq. (1), (2), we get

$$\frac{hc}{\lambda} = \frac{1}{2}kx^2 \tag{4}$$

During the process of compression; wavelength λ of given monochromatic light wave will be changing with time t due to this x will also change with time t. In eq. (4) h and c are constants also force constant k of given monochromatic light wave is constant. So by differentiating eq. (4) w.r.t. time t we get

$$-\frac{hc}{\lambda^2}\frac{d\lambda}{dt} = kx\frac{dx}{dt} \tag{5}$$

Rearranging eq. (5) we get

$$-\frac{hc}{\lambda^2}\frac{d\lambda}{dx} = kx \tag{6}$$

The R.H.S term of eq. (6) is nothing but the classical expression of force exerted by the body performing simple harmonic motion and negative sign in eq. (6) indicates, the compression and motion of monochromatic light wave is simple harmonic [3]. Arranging eq. (4), (6), we get following differential equation

$$\frac{d\lambda}{\lambda} = \frac{-2dx}{x} \tag{7}$$

After integrating eq. (7) we get

$$x = \sqrt{\frac{C_0}{\lambda}} \tag{8}$$

Where C_0 is an integration constant now by arranging eq. (3), (8), we get the change in wavelength of monochromatic light wave due to the compression and it can be written as

$$\Delta\lambda = -\frac{1}{n}\sqrt{\frac{C_0}{\lambda}} \tag{9}$$

Since n is total number of wavelengths which are undergoing compression and λ_0 is wavelength of monochromatic light wave after compression so obviously the length of compressed part of monochromatic light wave can be written as

$$x_0 = n\lambda_0 \tag{10}$$

Where x_0 is length of compressed part of monochromatic light wave. Arranging eq. (3), (8), (10), we get

$$x_0 = n\lambda - \sqrt{\frac{C_0}{\lambda}} \quad (11)$$

In eq. (11) λ, n and C_0 are constants for given monochromatic light wave so we can say that the length x_0 of compressed part of the given monochromatic light wave is constant also eq. (11) indicates that after certain limit wave cannot compress.

3. Discussion and Conclusions

Double slit experiment showed that the light behaves like a wave and work of James C. Maxwell showed that the light is an electromagnetic wave [4]. However for explanation of photoelectric effect Albert Einstein said that the light consists of photons [5]. If we apply compression mechanism of §2 for giving explanation of why does light show wave nature and particle nature in double slit experiment and in photoelectric effect respectively then things will be more general. When monochromatic light waves pass through double slits then waves won't compress so due to this waves won't change their wave nature to the particle nature and waves will easily pass through slits therefore waves will be able to show interference pattern. However in case of photoelectric effect when monochromatic light wave incident on the metal surface then this wave begins to compress due to the collision with electrons in metal surface and then this compressed part of the wave resembles like a particle. The explanation of photoelectric effect based on this study shows that, we can explain photoelectric effect without using the concept of photons and which was also shown by both Willis E. Lamb, Jr. and Marlan O. Scully but in different way [6]. We can apply same mechanism for explanation of dual nature of non-monochromatic light waves but in this case we will require more general reasoning. From this study it follows that, when light wave compress then light wave changes its wave nature to the particle nature and this compressed part of the wave resembles like a particle and every light wave when incident on the particle then it get compressed to the fixed amount. In present paper, I have tried to make sense between wave and particle nature of the light. However it will require further discussions on this study.

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