CME LIVE OPEN ACCESS

Journal of Theoretical Physics & Mathematics Research

Review Article

Study of Raman Effect, Photoelectric Effect and Compton Effect Using String Theory

M. Kumar[1], B. Sahoo[2] and S. Sahoo[3*]

[1]*Department of Physics, National Institute of Technology Durgapur, West Bengal, India*

[2]*Department of Physics, T. D. B. College, Raniganj, West Bengal, India.*

[3]*Department of Physics, National Institute of Technology Durgapur, West Bengal, India*

Corresponding Author: S. Sahoo, Department of Physics, National Institute of Technology Durgapur, West Bengal, India.

Received: 2023 Dec 14 **Accepted:** 2024 Jan 10 **Published:** 2024 Feb 02

Abstract

In string theory, photon and electron are considered as different vibrational modes of strings. In this work, we assume that Raman effect, Photoelectric effect and Compton effect can be visualized in string theory. We find out the force of interaction between photon and electron by calculating the time interval between incident photon and scattered photon in Raman effect and Compton effect as well as time interval between incidence of photon and emission of electron in photoelectric effect using Heisenberg's Uncertainty Principle. Then we calculate the force of interaction between two strings whose vibrational modes are photon and electron in string theory. Finally, we calculate the coupling constants of the two interacting strings.

Keywords: Raman Effect, Photoelectric Effect, Compton Effect, String Theory

PACs Nos.:78.30.-j, 84.60. Jt, 13.60. Fz, 11.25.-w

1. Introduction

In Raman effect, scattering of photons take place due to the interaction of electromagnetic waves with electron of an atom or a molecule [1-5]. Implication of Raman effect in Raman spectroscopy has been studied in Refs. [6-8]. Raman effect has also been discussed in femtoseconds, attoseconds [9]. Kumar and Sahoo have calculated the time interval in the scattering of photon by the electron in Raman effect which is of the order of 10^{-23} s-10^{-20} s [10]. In photoelectric effect, there is emission of electron when high energy electromagnetic waves such as X-rays are absorbed by matter [11-14]. Till now, no detectable time lag has been found in measuring the time interval between absorption of electromagnetic waves by the matter and emission of electron from the matter [15, 16]. It has been shown by Atkinson that the excitation of an atom takes place in less than 10^{-10} s [17]. Kumar and Sahoo have calculated the time interval between absorption of photon and emission of electron in photoelectric effect which is of the order of 10^{-23} s-10^{-20} s [10]. In Compton effect, a gamma photon collides with an electron in an atom serving as the target. Compton collision is an elastic collision between a photon and an electron which become predominant when the photon energy becomes large compared to the energy that holds the electron in an atom i.e., its binding energy. There is unequal energy sharing between the gamma photon and the electron which depends on the gamma scattering angle. In most cases which is likely to be happened, the photon is not scattered without any loss of power which is the case of forward scattering. In rare cases, the gamma photon bounces backward propelling the electron in forward direction which is the case of backscattering. In average cases, the gamma photon is scattered through a certain angle between 30-45 degrees [18].

In string theory, a photon is the vibrational mode of an open string of having finite length whereas an electron is also the vibrational mode of string of finite length both having different vibrational modes. Planck energy $E_p \sim 1/l_p$, where l_p is Planck length, energy of a photon $E \sim 1/l_s$, where l_s is length of the string. So, energies of incident photon and scattered photon are given by $E_1 \sim 1/l_{s1}$, $E_2 \sim 1/l_{s2}$, respectively where l_{s1} corresponds to length of string of incident photon and l_{s2} corresponds to length of string of scattered photon. Time in string theory t~l. In string theory, force of interaction between two strings is given by $F = g\, m_1 m_2/r^2$ where g is the coupling constant of open string with the electron in which g_1 is coupling constant of string with vibrational mode of that of incident photon and g_2 is coupling constant of string with vibrational mode of that of scattered photon. m_1, m_2 are masses of first and second string respectively and $m_1 \sim 1/l_{s1}$,$m_2 \sim 1/l_{s2}$. Also we have the relation in string theory for the Planck length l_p, length of the string l_s and the coupling constant of the string g as $l_p = g l_s$ [19-24]. In this paper, we assume that Raman effect, photoelectric effect and Compton effect can be visualized in string theory.

This paper is organized as follows: In section 2, we calculate the string's length of the photon and the electron using string theory in four-dimensional space-time. In section 3, we calculate the force of interaction between photon and electron during the scattering of photon by the electron in Raman effect in string theory. In section 4, we estimate the force of interaction between photon and electron during the incidence of photon and emission of electron in Photoelectric effect in string theory. In section 5, we calculate the force of interaction between photon and electron in Compton effect during the scattering of photon by the electron in string theory. Finally, we present our conclusions in section 6.

1.1. String's Length of the Photon and the Electron in String Theory

In this section, we calculate the string's length corresponding to the photon l_s and the string's length corresponding to the electron l_{se} in string theory. Then calculate the coupling constant of the photon g with the electron. For this, we consider Raman scattering of light by the electron for the case when the photon is scattered with the same energy initially it has, i.e.

$E_1 = E_2 = E$ imply $\nu_1 = \nu_2 = \nu$. (1)

In this case, the energy difference between incident photon and scattered photon is given by,

$\Delta E = c\Delta p = E_2 - (-E_1) = 2E$. (2)

Using Heisenberg's Uncertainty Principle $\Delta E \Delta t \geq \hbar/2$ in equation (2), we can find the time interval as,

$$\Delta t = \frac{\hbar}{4E} = \frac{\hbar}{4h\nu} = \frac{1}{8\pi\nu}. \quad (3)$$

In string theory, $E \sim 1/l_s$, Δt can be given by putting $\hbar=1$ in equation (3) as,

$$\Delta t \sim \Delta l = \frac{l_s}{4}. \quad (4)$$

Similarly, for other cases (when the photon will scatter with energy greater than the incident energy and when the photon will scatter with energy lesser than its incident energy) also, since in string theory $t \sim l$ implying $\Delta t \sim \Delta l$ as given in equation (4). So, we obtain the change in string's length due to the coupling of the two strings from equation (4).

Force of interaction between photon and electron during the scattering of photon by the electron can be calculated using the relation that the impulse is equal to the change in momentum as:

$$F\Delta t = \frac{E_2}{c} - \left(-\frac{E_1}{c}\right) = \frac{2E}{c}. \quad (5)$$

From equation (5), we can calculate the force of interaction between photon and electron as,

$$F = \frac{2E}{c\Delta t} = \frac{2h\nu}{c\Delta t}. \quad (6)$$

Putting $\hbar=c=1$ in equation (6) and $E \sim 1/l_s$, along with using equation (4), we find out the force of interaction between two strings in string theory as

$$F = \frac{8}{l_s^2}. \quad (7)$$

From equations (6), it is also clear that $1/l_s = h\nu = 2\pi\hbar c/\lambda$. So, for $\hbar=c=1$ we will have

$l_s = \lambda/2\pi$. (8)

Equation (8) gives the value of string's length in string theory. In analogy to equation (8), the string's length corresponding to electron in string theory can be given by,

$l_{se} = \lambda_0/2\pi$. (9)

In equation (9), $\lambda_0 = \hbar/m_e c$ is Compton wavelength of the electron. The value of string's length calculated using equation (9) is $l_{se} \approx 6.15\times10^{-14}$ m. Equating equation (7) with

$F = g\frac{1}{l_s}\frac{1}{l_{se}}\frac{1}{r_e^2}.l^2$, we will get the coupling constant as:

$$g = \frac{8}{l^2}\frac{l_{se}}{l_s}r_e^2 \quad (10)$$

In equation (10), we have l is the length of the string formed due to the coupling of the strings corresponding to photon and that to the electron. We can say that l is length of the string formed when two strings join together and exist for time Δt, after which it again splits into two strings one corresponding to electron and another corresponding to scattered photon.

Using equation (10), we can calculate the coupling constant between the two strings of length l_{se} and l_s for electron and photon respectively whereas r_e is distance of interaction between the two interacting strings. In order to calculate the coupling constant, we put the value $l = l + \Delta l$ where $\Delta t \sim \Delta l = l_s/4$ as from equation (4), we have $l = 5/4\, l_s$.

1.2. Force of Interaction Between Photon and Electron During the Scattering of Photon by the Electron in Raman Effect

In the scattering of photon by the electron, three cases arise. In the first case, the photon will scatter with energy greater than the incident energy. In the second case, it will scatter with energy lesser than its incident energy. In third case, it will scatter with energy equal to the incident energy [1-4]. Let, the initial energy of the incident photon is given by

$E_1 = h\nu_1$ (11)

where, E_1 and ν_1 are the initial energy and initial frequency of the incident photon respectively. In string theory, the initial energy of the incident photon is given as:

$E_1 = 1/l_{s1}$ (12)

After collision with the electron of an atom, the photon will return back with energy

$E_2=h\nu_2$ (13)

where, E_2 and ν_2 are the final energy and final frequency of the scattered photon respectively. In string theory, the final energy of the scattered photon is given as:

$E_2=1/l_{s2}$ (14)

In the first case, when the photon is scattered with energy greater than its incident energy, then we have

$E_2>E_1$ $\nu_2>\nu_1$ and $l_{s2}<l_{s1}$. (15)

In this case, the energy difference between incident photon and scattered photon is given by,

$\Delta E=E_2-E_1=h(\nu_2-\nu_1)$. (16)

The value of ΔE calculated using equation (16) for λ_2=5000A^0 and λ_1=6000A^0 is ΔE=0.45 eV. Using Heisenberg's Uncertainty Principle that is, $\Delta E\Delta t\geq\hbar/2$ in equation (16), we find the time interval

$$\Delta t=\frac{\hbar}{2h(\nu_2-\nu_1)}=\frac{1}{4\pi(\nu_2-\nu_1)}. \quad (17)$$

The value of Δt calculated using equation (17) for λ_2=5000A^0 and λ_1=6000A$_0$ is $\Delta t=8.0\times10^{-16}s$. In string theory, Δt is given by,

$$\Delta t\sim\Delta l=\frac{1}{2}\left(\frac{1}{l_{s2}}-\frac{1}{l_{s1}}\right)^{-1}. \quad (18)$$

As in string theory $t\sim l$ which implies that $\Delta t\sim\Delta l$. So, we obtain the change in string's length due to the coupling of the two strings from equation (18). Force of interaction between photon and electron during the scattering of photon by the electron can be calculated using the relation that the impulse is equal to the change in momentum as:

$$F\Delta t=\frac{E_2}{c}-\left(-\frac{E_1}{c}\right). \quad (19)$$

Using equations (17) and (19), we find the force of interaction between photon and electron as,

$$F=\frac{h(\nu_2+\nu_1)}{c\Delta t}=\frac{4\pi h}{c\Delta t}(\nu_2^2-\nu_1^2). \quad (20)$$

The value of force calculated using equation (20) for λ_2=5000A^0 and λ_1=6000A^0 is F=3.1×10^{-22} N.

Putting $\hbar$=c=1 in equation (20), we find out the force interaction between two strings in string theory as

$$F=\left(\frac{1}{l_{s2}^2}-\frac{1}{l_{s1}^2}\right). \quad (21)$$

Equating equation (21) with $F=g_1\frac{1}{l_{s1}}\frac{1}{l_{se}}\frac{1}{r_e^2}.l^2=g_2\frac{1}{l_{s2}}\frac{1}{l_{se}}\frac{1}{r_e^2}.l^2$,

we will get the coupling constants of the strings corresponding to the incident photon and that to the scattered photon as:

$$g_1=\frac{2}{l^2}l_{s1}l_{se}r_e^2\left(\frac{1}{l_{s2}^2}-\frac{1}{l_{s1}^2}\right) \quad (22)$$

and

$$g_2=\frac{2}{l^2}l_{s2}l_{se}r_e^2\left(\frac{1}{l_{s2}^2}-\frac{1}{l_{s1}^2}\right). \quad (23)$$

In equations (22) and (23), l which is the length of the string formed due to the coupling of the strings corresponding to photon and that to the electron has been introduced inorder to make the coupling constants dimensionless quantity. Putting the values $l_{s1}=9.55\times10^{-8}$ m and $l_{s2}=8.0\times10^{-8}$ m in the equations (22) and (23), we will get the values of the coupling constants as $g_1=3.1\times10^{-22}$ and $g_2=3.65\times10^{-22}$.

In the second case, when the photon is scattered with energy lesser than its initial energy, then we have

$E_2<E_1$ $\nu_2<\nu_1$ and $l_{s2}>l_{s1}$ (24)

In this case, the energy difference between incident photon and scattered photon is given by,

$\Delta E=E_1-E_2=h(\nu_1-\nu_2)$. (25)

The value of ΔE calculated using equation (25) for λ_1=5000A^0 and λ_2=6000A^0 as ΔE=0.45 eV. Using Heisenberg's Uncertainty Principle in equation (25), we can find the time interval as,

$$\Delta t=\frac{\hbar}{2h(\nu_1-\nu_2)}=\frac{1}{4\pi(\nu_1-\nu_2)}. \quad (26)$$

The value of Δt calculated using equation (26) for λ_1=5000A^0 and λ_2=6000A^0 as Δt=8.0×10^{-16} s. In string theory, Δt is given by,

$$\Delta t\sim\Delta l=\frac{1}{2}\left(\frac{1}{l_{s1}}-\frac{1}{l_{s2}}\right)^{-1}. \quad (27)$$

In this case also similar to previous case, since in string theory t~l which implies that Δt~Δl. So, we obtain the change in string's length due to the coupling of the two strings from equation (27). Force of interaction between photon and electron during the scattering of photon by the electron can be calculated using the relation that the impulse is equal to the change in momentum as:

$$F\Delta t=\frac{E_1}{c}-\left(-\frac{E_2}{c}\right). \quad (28)$$

Using equations (27) and (28), we can find out the force of interaction between photon and electron as,

$$F=\frac{h(\nu_1+\nu_2)}{c\Delta t}=\frac{4\pi h}{c\Delta t}(\nu_1^2-\nu_2^2). \quad (29)$$

The value of force calculated using equation (29) for λ_1=5000A^0 and λ_2=6000A^0 is F=3.1×10^{-22} N.

Putting $\hbar$=c=1 in equation (29), we find out the force interaction between two strings in string theory as

$$F=\left(\frac{1}{l_{s1}^2}-\frac{1}{l_{s2}^2}\right). \quad (30)$$

In equation (30) also we have l is the length of the string formed due to the coupling of the strings corresponding to photon and that to the electron. Equating equation (30) with

$$F = g_1 \frac{1}{l_{s1}} \frac{1}{l_{se}} \frac{1}{r_e^2} . l^2 = g_2 \frac{1}{l_{s2}} \frac{1}{l_{se}} \frac{1}{r_e^2} . l^2,$$

we will get the coupling constants of the strings corresponding to the incident photon and that to the scattered photons as:

$$g_1 = \frac{2}{l^2} l_{s1} l_{se} r_e^2 \left(\frac{1}{l_{s1}^2} - \frac{1}{l_{s2}^2}\right) \quad (31)$$

and

$$g_2 = \frac{2}{l^2} l_{s2} l_{se} r_e^2 \left(\frac{1}{l_{s1}^2} - \frac{1}{l_{s2}^2}\right). \quad (32)$$

In equations (31) and (32), l which is the length of the string formed due to the coupling of the strings corresponding to photon and that to the electron has been introduced in order to make the coupling constants dimensionless quantity. Putting the values l_{s1}=8.0×10^{-8} m and l_{s2}=9.55×10^{-8} m in the equations (31) and (32), we will get the values of the coupling constants as g_1=3.65×10^{-22} and g_2=3.1×10^{-22}.

For the third case of the Raman effect when incident photon and the scattered photon have same energy, the value of Δt calculated using equation (3) for $\lambda_1=\lambda_2=\lambda$=5000A^0 is Δt=6.63×10^{-17} s and the force calculated using equation (6) is F=4.0×10^{-11} N. The value of string's length calculated using equation (9) is l_{se}≈6.15×10^{-14} m. The value of string's length calculated using equation (8) for third case of Raman effect is l_s≈7.15×10^{-8} m. The value of the coupling constant between the two interacting strings of length l_{se} and l_s for electron and photon respectively is calculated using equation (10) as g=5.0×10^{-19}.

1.3. Force of Interaction Between Photon and Electron During the Incidence of Photon and Emission of Electron in Photoelectric Effect

The energy difference during the absorption of electromagnetic waves by the electron can be described as coupling of open string corresponding to the photon is given as:

ΔE=hν. (33)

Using Heisenberg's Uncertainty Principle, we will get time interval in the absorption of photon by the electron as:

$$\Delta t = \frac{\hbar}{2h\nu} = \frac{1}{4\pi\nu}. \quad (34)$$

The value of ΔE and Δt are calculated using equation (33) and (34) for λ=4584 A^0 as ΔE=2.71 eV and Δt=1.22×10^{-16} s respectively. From equation (34), the value of Δt in string theory is given by putting ℏ=1 as,

$\Delta t \sim \Delta l = l_s/2$. (35)

In equation (35), l_s is the string length of the photon absorbed by the electron . Force of interaction of electromagnetic waves with electron during the absorption of photon by electron and emission of electron in photoelectric effect can be calculated using the relation i.e., impulse is equal to the change in momentum as:

$$F\Delta t = m_e \gamma v - \left(-\frac{E}{c}\right). \quad (36)$$

The force of interaction is calculated using equations (34) and (36) as,

$$F = \frac{(m_e \gamma v + h\nu/c)}{\Delta t}. \quad (37)$$

The force of interaction calculated using equation (37) for λ=4584A^0 and Δt=1.2×10^{-16} s for Cesium metal with work function 1.95 eV, the velocity of the ejected electron v=0.52×10^6 m/s and γ=1.01523 using mass of electron m_e=9.1×10^{-31} kg is calculated as F=4.0×10^{-9} N.

Putting ℏ=c=1 in equation (37) and using equation (35), we find out the force interaction between two strings in string theory as

$$F = \frac{1}{l^2} . \frac{2}{l_s} \left(\frac{\gamma\beta}{l_{se}} + \frac{1}{l_s}\right). \quad (38)$$

In equation (38), l is the length of the string formed due to the coupling of the strings corresponding to absorbed photon and that to the electron, $\beta = \frac{v}{c}$ and $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ has been used in order to make velocity dimensionless, l_{se} is string's length whose vibrational mode is electron whereas l_s is string's length whose vibrational mode is incident photon. Equating equation (38) with $F = g \frac{1}{l_s} \frac{1}{l_{se}} \frac{1}{r_e^2}$, we will get the coupling constant as:

$$g = \frac{2}{l^2} l_{se} r_e^2 \left(\frac{\gamma\beta}{l_{se}} + \frac{1}{l_s}\right) \quad (39)$$

Using equation (39), we can find out the coupling constant between the two strings of string length l_se and l_s one for vibrational mode of electron and the other for vibrational mode of photon respectively whereas r_e is distance of interaction between the two interacting strings. The value of the coupling constant between the two interacting strings of length l_se and l_s for electron and photon respectively in Photoelectric effect can be calculated by putting the values l_s =7.3×10^{-8} m, β=0.00173 along with the other values in equation (39) as g=1.2×10^{-18}.

1.4. Force of Interaction Between Photon and Electron in Compton Effect During the Scattering of Photon by the Electron

In Compton effect, when the photon is scattered with the energy lesser or equal to initially it has, we have

$E_2 \le E_1$ $\nu_2 \le \nu_1$ and $l_{s2} \ge l_{s1}$. (40)

In Compton effect we have the expression [18]:

$h\nu_1 \nu_2 (1-\cos\theta) = m_e c^2 (\nu_1 - \nu_2)$ (41)

In equation (40), θ is the angle between the scattered photon and the recoiled electron whereas m_e is mass of electron can be re-expressed as:

$(h\nu_1)(h\nu_2)(1\text{-}\cos\theta)=m_e c^2 (h\nu_1\text{-}h\nu_2)$ (41)

The energy difference between incident photon and scattered photon is given by,

$$\Delta E = E_1 - E_2 = (h\nu_1 - h\nu_2) = \frac{(h\nu_1)(h\nu_2)}{m_e c^2}(1 - \cos\theta). \quad (42)$$

The value of ΔE calculated using equation (42) for $\lambda_1=100A_0$ and $\lambda_2=1000A^0$ as ΔE=112 eV. Force of interaction between photon and electron during the scattering of photon by the electron can be calculated using the relation that the impulse is equal to the change in momentum as:

$F\Delta t=m_e \gamma v$ (43)

Equation (42) can be written with string theory as:

$F\Delta t=\gamma\beta/l_{se}$. (44)

Force of interaction between photon and electron during the scattering of photon by the electron in string theory by putting the values of the coupling constants as derived from the equation (10) is given as;

$$F_1 = g_1 \frac{1}{l_{s1}} \frac{1}{l_{se}} \frac{1}{r_e^2} . l^2 = \frac{8}{l_{s1}^2} \quad (45)$$

$$F_2 = g_2 \frac{1}{l_{s2}} \frac{1}{l_{se}} \frac{1}{r_e^2} . l^2 = \frac{8}{l_{s2}^2} \quad (46)$$

Using the equations (44) and (45), the coupling time for incident string with the electron is calculated as:

$$\Delta t_1 \sim \Delta l_1 = \gamma\beta \frac{1}{l_1^2} \frac{l_{s1} r_e^2}{g_1}, \quad (47)$$

while using the equations (44) and (46), the coupling time for scattered string with the electron is calculated as:

$$\Delta t_2 \sim \Delta l_2 = \gamma\beta \frac{1}{l_2^2} \frac{l_{s2} r_e^2}{g_2} \quad (48)$$

Total time of interaction between the photon and the electron considering the interaction between the photon and the electron as the interaction of two strings is calculated by adding the equations (47) and (48) as:

$$\Delta t \sim \Delta l = \gamma\beta r_e^2 \left(\frac{l_{s1}}{g_1 l_1^2} + \frac{l_{s2}}{g_2 l_2^2} \right) \quad (49)$$

In equations (47), (48) and (49), l is the length of the string formed due to the coupling of the strings corresponding to photon and that to the electron when two strings join together and exist for time Δt, after which it again splits into two strings one corresponding to electron and another corresponding to scattered photon.

2. Discussions and Conclusions

In this paper, we explain the phenomenon of coupling of the strings corresponding to incident photon with the string corresponding to the electron. The coupled string having length l exsits which is due to coupling between the incidence or absorption of photon and the scattering of the photon or ejection of electron for a time interval Δt which has been calculated using the Heisenberg's Uncertainty Principle. We find that time interval in the scattering of electromagnetic waves by the electron in Raman effect and Compton effect as well as absorption of photon and emission of electron in Photoelectric effect. After a period of time Δt, the coupled string of length l again splits into two strings which correspond to the scattered photon or the ejected electron in Photoelectric effect and recoiled electron in the case of Compton effect. We have calculated the force of interaction between photon and electron in different cases. We have also calculated the coupling constants between the two strings of length l_{se} and l_s for electron and photon respectively for Raman effect, Photoelectric effect and the Compton effect. The values for different parameters we have calculated in our work are the optimum values. The value of the string length for electron calculated $l_{se}\approx6.15\times10^{-14}$ m in maximum value. l_se must be less than size of the electron or the Compton wavelength of the electron. In Raman effect the coupled string having length l exists for time, $\Delta t=8.\times10^{-16}$ s for first and second cases and for time, $\Delta t=6.63\times10^{-17}$ s for third case. The force of interaction between to strings calculated for $\lambda_1=5000A^0$ and $\lambda_2=6000A^0$ is $F=3.1\times10^{-22}$ N for first and second cases of Raman effect while the value of force of interaction calculated for $\lambda_1=\lambda_2=\lambda=5000A^0$ is $F=4.0\times10^{-11}$ N in third case of Raman effect. The values of the string's length calculated as $l_{s1}=9.55\times10^{-8}$ m and $l_{s2}=8.0\times10^{-8}$ m in the equations (22) and (23), are the maximum values which cannot exceed the wavelength of light. So, the string's length must be always lesser than the calculated values. The values of the coupling constants calculated as $g_1=3.1\times10^{-22}$ and $g_2=3.65\times10^{-22}$ are minimum values below which, there will be no coupling between photon and electron. So, the coupling constants will always be greater than the calculated values. Similarly, the values of the string length calculated for second case are $l_{s1}=8.0\times10^{-8}$ m and l_s2=9.55×10^{-8} m in the equations (31) and (32), and the values of the coupling constants are calculated as $g_1=3.65\times10^{-22}$ and $g_2=3.1\times10^{-22}$. The string's length calculated for third case of Raman effect using equation (8) is $l_s\approx7.15\times10^{-8}$ m and the coupling constant is calculated as $g=5.0\times10^{-19}$.

In Photoelectric effect there is coupling of the two strings for the time period of $\Delta t=1.22\times10^{-16}$ s . The force of interaction between the two interacting strings in the case of Photoelectric effect is as $F=4.0\times10^{-9}$ N. The value of the coupling constant between the two interacting strings of length l_{se} and l_s for electron and photon respectively in Photoelectric effect can be calculated by putting the values $l_s=7.3\times10^{-8}$ m, β=0.00173 along with the other values in equation (39) as $g=1.2\times10^{-18}$.

Using the values of the coupling constants g, g_1 and g_2 from equations (10), (22), (23), (31) we have calculated the time period of the coupled string from equation (49) in the case of Compton effect. In every case Δt is the time period of joining of two strings and the splitting up of the two strings. Using the values of g_1 and g_2, we can also find out the force of interaction between the two strings using equations (44) and (45) in Compton effect. We can verify our results using the relation $l_p=gl_s$. For the first and second cases of Raman effect, $g_1 l_{s1}=3.0\times10^{-29}$, for third case $gl_s=3.6\times10^{-26}$. In the case of Photoelectric effect, $gl_s=8.8\times10^{-26}$. The values of $l_p=gl_s=10^{-35}$ m in four dimensional space-time as in quantum gravity, the size of string corresponding to graviton is of Planck size. But in the case of string theory in higher dimensional space-time, string's length is more than Planck length. For example, in the case of six dimensions, $l_p \sim 10^{-20}$ m as the value of gravitational constant, $G_N \sim l_p^2 = g^2 l_s^2$ is changed in higher dimensional space-time. So, our verification shows that $l_p \sim gl_s$ in higher dimensional i.e., more than four-dimensional string theory.

In the last, a very important thing we want to discuss that in all the cases, the value of coupling constants we have calculated is very much less means there is very less probability of the coupling of photon with the electron. As discussed in section 2, for the case that there must be coupling of photon with the electron we must have g=1. Taking the value $l_{se}=10^{-25}$ m, and putting all the parameters in equation (10), we will have $l_s \approx 10^{-18}$ m. So, $gl_s = 10^{-18}$ m$\sim l_p$ in higher dimensional string theory. Thus, we have come to conclusions that the string's length and the coupling constant of the string varies with the number of dimensions in string theory.

References

1. Raman, C. V., & Krishnan K. S. (1928). Nature,121, 507.
2. Raman, C. V., & Krishnan, K. S. (1928). The optical analogue of the Compton effect. Nature, 121(3053), 711-711.
3. Raman, C. V., & Krishnan K. S. (1928). Nature,121, 12.
4. Raman, C. V. (1929). Investigations of the Scattering of Light. Nature, 123(3089), 50-50.
5. Landsberg, G., & Mandelstam L. (1928), Naturwissenschaften, 16, 557.
6. Opel, M., Venturini, F., & der Wissenschaften, B. A. (2002). Raman scattering in solids. European Pharmaceutical Review, 7(3), 76-82.
7. Loudon, R. (1963). Theory of stimulated Raman scattering from lattice vibrations. Proceedings of the Physical Society, 82(3), 393.
8. Loudon, R. (2001). The Raman effect in crystals. Advances in Physics, 50(7), 813-864.
9. Zheltikov, A. M. (2011). The Raman effect in femto-and attosecond physics. Physics-Uspekhi, 54(1), 29.
10. Kumar, M., & Sahoo, S. (2012). Time interval and lattice vibration in Raman effect, photoelectric effect and plane mirror reflection. Modern Physics Letters B, 26(18), 1250115.
11. Beiser, A. (2003). Concepts of modern physics.
12. Serway, R. A. (2005). Student solutions manual for Modern physics. THOMSON*-BROOKS/COLE.
13. Sears, F. W., Zemansky, M. W., & Young, H. D. (1998). University Physics, Sixth Edition, Narosa Publishing House, New Delhi.
14. Hertz, H. (1887). Ueber einen Einfluss des ultravioletten Lichtes auf die electrische Entladung. Annalen der Physik, 267(8), 983-1000.
15. Lawrence, E. O., & Beams, J. W. (1928). The element of time in the photoelectric effect. Physical Review, 32(3), 478.
16. Brandl, M. (2001). Project Physnet-MISN-0-213-The Photoelectriceffect, 11/08.2001.
17. Atkinson, d'E. (1927). Roy. Soc. Proc. A116, 81.
18. Gasiorowicz, S. (2007). Quantum physics. John Wiley & Sons.
19. Wray, K. (2011). An introduction to string theory. notes.
20. Greene, B. R., Morrison, D. R., & Polchinski, J. (1998). String theory. Proceedings of the National Academy of Sciences, 95(19), 11039-11040.
21. Evans, N. (2003). String Theory meets QCD, Phys. World, 35-38.
22. Maldacena, J. (1999). The large-N limit of superconformal field theories and supergravity. International journal of theoretical physics, 38(4), 1113-1133.
23. Karch, A., Katz, E., & Weiner, N. (2003). Hadron Masses and Screening from Anti–de Sitter Space Wilson Loops. Physical review letters, 90(9), 091601.
24. Witten, E. (1998). Anti de Sitter space and holography. arXiv hep-th/9802150.