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Numerical Analysis of Photon and Electron Size, and Verifying One to One Correspond Rule of Einstein Photoelectric Effect.

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Abstract— In this paper we compare the cross-section area of electron and red photon and and found that the cross-section area of red photon is greater than that of electron. The value is cross-section area of red photon is found to be $\approx 6.5\times 10^{-19}\,cm^2$ and electron is found to be , $A_e^s = 99.882144\times 10^{-26}\,cm^2$ approximately. Moreover found that the cross-section area of one photon is equal to approx. 650556.954 times cross-section area of electron. This implies or support one of the principle or rule of Einstein photoelectric effect i.e. suitable energy photon kick one electron by one photon (One photon kick out one electron) from surface of material.

Index Terms—Cross-section Area, Red Photon, Electron, Photoelectric Effect etc.

1 INTRODUCTION

Albert Einstein explained the photoelectric effect postulating that luminous energy can be absorbed or emitted only in discrete amounts, called quanta. The light quantum behaved as an electrically neutral particle and was called "photon". The Planck-Einstein relation, E = hν, connects the photon energy with its associated wave frequency. Photon has a well defined energy, one may argue that it should also have a momentum. Compton is credited with studying the change in momentum during the collision of a photon with an electron and photons need not transfer energy only to electrons. They could also transfer energy to the atoms in a molecule enhancing their vibrational or rotational energy [1,2].

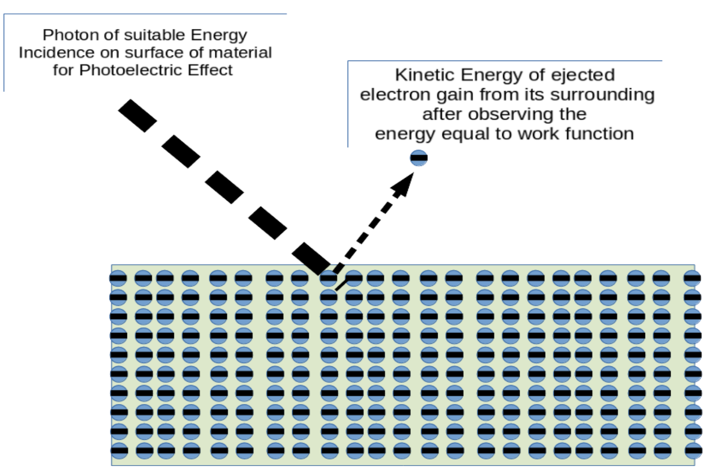

Figure 1: Photoelectric Phenomena when suitable energy of photon incidence on surface of a material atom.

Einstein's rules for the photoelectric effect are the following:

- The flux of photons is proportional to the intensity of the incident light.
- The maximal energy of photoelectrons is given by

$$\frac{1}{2} m v_{max}^2 = hf - \phi$$

where φ is the work function of the substance, m is mass of electron, v_{max}= maximum velocity of electron, h=planks constant and f= frequency of incidence photon. Hence, the emission of the electron is possible only if hf− φ > 0; thus, the redbound f_{red} = φ/h, does not depend on the intensity of the light which, agrees with Lenard's observations .

- Respectively, the stopping voltage should satisfy the inequality $-eU_{stop} > hf - \varphi$, where e is charge of electron and U_{stop} is stopping voltage [3].

Let hf is the suitable amount of energy incidence on the surface of material atom and capable to eject the electron form a atom of material to causes the photoelectric phenomena. When photon energy incidence on the surface, the partial energy of photon i.e. the amount of energy which fall on the surface of electron is observed by electron and electron fulfill the criteria of work function and then the remaining energy of same photon surrounding to electron is gain observed for kinetic energy of electron. Let φ be the amount of observed energy by electron for work function when photon incidence on its surface and K.E is the kinetic energy of electron gain from its surrounding then from photoelectric effect we have,

$$hf = \phi + K.E$$ [4] where,

$$\phi = q_T\left(K\sum_{k=1}^{N}\frac{q_k}{r_{kT}} + K\sum_{m=1}^{N}\frac{q_m}{r_{mT}} - K\sum_{i=1}^{N}\frac{Q}{r_i} - K\sum_{j=1}^{N}\frac{Q_{sj}}{r_{jT}}\right) -- q_T\left(\sum_{n>1}^{N}\sum_{p=1}^{N'}\frac{q^{n-1}}{32\pi^2 m^2 \omega_0^3 R_{pqT}^6}\right) - \alpha\frac{e^{-\mu r}}{r} + E_{VC}$$

This mean the observed energy by electron is distributed into different parts or used for different purpose to leave the atom [5].

2 REVIEW

The total atomic cross section σ_{tot} can be written as the sum over the cross sections for the most-probable individual processes by which photons interact with atoms $\sigma_{tot} = \sigma_{pe} + \sigma_{incoh} + \sigma_{coh} + \sigma_{pair} + \sigma_{trip} + \sigma_{ph.n.}$ in which σ_{pe} (or τ) is the atomic photoeffect cross section, σ_{incoh} and σ_{coh} are the incoherent (Compton) and coherent (Rayleigh) cross sections, respectively. σ_{pair} (or κ_n) and σ_{trip} (or κ_e) are the cross sections for electron–positron pair production (creation) in the field of the nucleus and in the field of the atomic electrons ('triplet' production), respectively [6].

We define the electron Thomson cross section by integrating over all the angles: $\approx 6.65\times 10^{-25}\,cm^2$ and classical electron radius,

$$r_0 = \frac{e^2}{m_e c^2} = 2.82\times 10^{-13}\,cm \quad [7].$$

The result of the experiment was negative and Mohler expressed the result in his article in terms of a limit on the cross section □ for photon-photon scattering (□ < 6 × 10−17 □□²) [8].

3 METHODOLOGY

Let us consider the shape of an atom is sphere with radius (r_s) and surface area (A_a^s). Since the radius of an silicon atom is 111pm=111x10-12m.

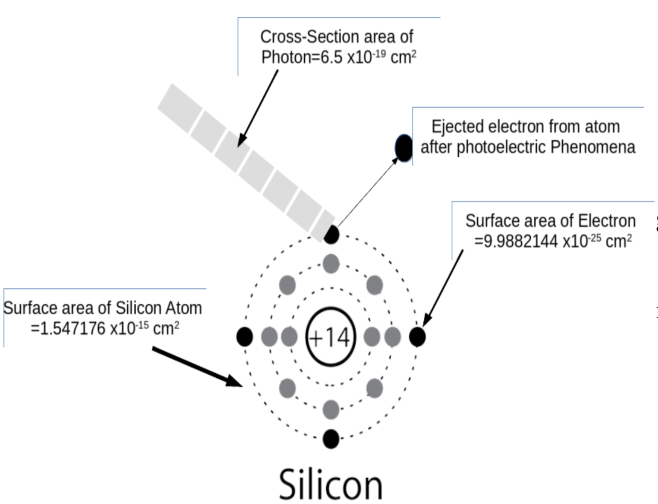

Figure 2: Phenomena of absorption of energy by electron when photon incidence on it surface.

Figure 2 described the details of how the energy of photon is observed by electron and one photon eject one electron in photoelectric effect. In figure 2 we see that the area of silicon atom is greater than that of photon and electron. For more clear to understand the phenomena absorption of energy of photon by electron in in figure 2 show that the light and dash line indicate photon having cross-section area greater than electron incidence on electron surface. In this cases we seen that certain part of photon cover whole electron i.e. the cover or contact point of electron and photon implies the observation of energy by electron and the remain part of photon surrounded the electron. When they contact to each other electron observed energy from contact surface of photon and trying to goes apart from an atom but to go apart from atom electron need more extra energy and this energy electron gain from the remain contact part of photon, which is also called kinetic energy of electron.

To make read more clear, here we find the area of atom, electron and photon below and compare these area to each other and related it to one to one correspond of Einstein photon electric rule. Because of the size of electron and photon this rule is one possible i.e. size of photon is greater than that of electron. If sized of photon is less than the size of electron then the probability of incidence photon on electron more than one and it doesn't follow the Einstein photoelectric one to one correspond.

We have the surface area of silicon atom

$$A_a^s = 4\pi r_s^2 = 4\times 3.14\times(111\times 10^{-12}\,m)^2$$

$$A_a^s = 12.56\times 12321\times 10^{-24}\,m^2 = 154751.76\times 10^{-24}\,m^2$$

$$A_a^s = 154751.76\times 10^{-24}\times 10^4\,cm^2 = 154751.76\times 10^{-20}\,cm^2$$
……….(1)

Now classically the radius of an electron we have

$$r_e = \frac{e^2}{m_e c^2} = 2.82\times 10^{-13}\,cm \quad [4].$$

Then the surface area of electron

$$A_e^s = 4\pi r_e^2 = 4\times 3.14\times(2.82\times 10^{-13}\,cm)^2$$

$$A_e^s = 12.56\times 7.9524\times 10^{-26}\,cm^2$$

$$A_e^s = 99.882144\times 10^{-26}\,cm^2$$
………….(2)

We have from **[9]** the cross-section area of red photon

$$A_p \approx 6.5\times 10^{-23}\,m^2 \approx 6.5\times 10^{-19}\,cm^2$$
…..(3)

Now taking the ratio of equation (1) with equation (2) we get

$$\frac{A_a^s}{A_e^s} = \frac{154751.76\times 10^{-20}\,cm^2}{99.882144\times 10^{-26}\,cm^2}$$

$$\frac{A_a^s}{A_e^s} = 1548.343594 \times 10^{-20+26} = 1548.343594 \times 10^6$$ ……………..(4)

This equation said that the maximum number of electron can incidence on one silicon atom of radius 111pm from any direction is approx. 1548.343594 x 10^6. This mean inside one atom of silicon we can fit 1548.343594 x 10^6 electron or moreover the surface are of consider atom is 1548.343594 x 10^6 times greater than the surface area of electron.

$$A_a^s = 1548.343594 \times 10^6 A_e^s$$ ……………….(5)

Similarly, taking the ratio of equation (1) with equation (3) we get,

$$\frac{A_a^s}{A_p} = \frac{154751.76 \times 10^{-20} cm^2}{6.5 \times 10^{-19} cm^2}$$

$$\frac{A_a^s}{A_p} = 23807.96308 \times 10^{-20+19}$$

$$\frac{A_a^s}{A_p} = 23807.96308 \times 10^{-1} = 2380.796308$$ …...(6)

This equation said that the maximum number of photon incidence on one silicon atom of radius 111pm from any direction is approx. 2380.796308 . This mean inside one atom of silicon we can fit 2380.796308 electron or more over the surface are of consider atom is 2380.796308 times greater than the surface area of electron.

$$A_a^s = 2380.796308 A_p$$ …………………….(7)

Now from (5) and (7) we have

$$1548.343594 \times 10^6 A_e^s = 2380.796308 A_p$$

$$A_p = \frac{1548.343594 \times 10^6}{2380.796308} A_e^s = 0.650346901 \times 10^6 A_e^s$$

$$A_p = 650346.9401 A_e^s$$ …………………….(8)

Also taking the ratio of (3) and (2) we get

$$\frac{A_p}{A_e^s} = \frac{6.5 \times 10^{-19} cm^2}{99.882144 \times 10^{-26} cm^2}$$

$$\frac{A_p}{A_e^s} = 0.06507669679 \times 10^{-19+26} = 0.06507669679 \times 10^7$$

$$\frac{A_p}{A_e^s} = 650766.9679$$

$$A_p = 650766.9679 A_e^s$$ …………………...(9)

From equation (8) and equation (9) we can see that the cross section area of one red photon is equal to approx. 650556.954 [On taking average of two date from equation (8) and (9)] electron cross-section area.

4 RESULT AND CONCLUSION

Here we have calculated the numerical value of cross-section area of atom, photon and electron with the help of silicon atom and found to be

$$\approx 154751.76 \times 10^{-20} cm^2 \equiv 1.547176 \times 10^{-15} cm^2,$$
$$\approx 6.5 \times 10^{-19} cm^2, \approx 9.9882144 \times 10^{-25} cm^2$$

respectively. This numerical value said that area of atom is greater than photon and photon is greater than electron i.e.

$$1.547176 \times 10^{-15} cm^2 > 6.5 \times 10^{-19} cm^2 > 9.9882144 \times 10^{-25} cm^2$$
.

This show that if a photon has sufficient energy to kick out the electron from material atom, electron was cover by incidence photon and the energy of photon is distributed to electron and its surrounding for photoelectric effect. Due to this greater area of photon than that of electron, photon are capable to eject or kick out from atom for photoelectric effect and follow the one to one correspond phenomena i.e. one photon eject one electron if incidence photon has sufficient energy for photoelectric effect. This is only possible when photon cross-section area is greater than that of electron and less than that of atom.

5 CONCLUSION

Numerically, taking the standard value we have calculate the areas of consider atom, photon, and electron and found as

$$1.547176 \times 10^{-15} cm^2 > 6.5 \times 10^{-19} cm^2 > 9.9882144 \times 10^{-25} cm^2$$

order. This proof the one-one corresponding relation of Einstein photoelectric effect i.e. one photon eject one electron from surface of material atom. If not i.e. photon cross-section area is greater than atom energy distribution of incidence photon is goes to multi-atom and energy is observed by them so no any phenomena are seed in photoelectric effect. Similar if incidence photon has small cross-section area then electron cannot observed the total energy of incidence photon. Therefore for one to one correspond the cross-section area of photon is greater than electron surface area and less than atom surface area.

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