*IOSR Journal Of Applied Physics (IOSR-JAP)*
*e-ISSN: 2278-4861.Volume 15, Issue 4 Ser. I (July. – August. 2023), PP 01-04*
*www.Iosrjournals.Org*

# Novel Equation for Photo-Electric Effect

## *The Equation Based on the Frequencies Alone*

Bhargava R. Kotur
*bhargava.kotur@gmail.com*
*AdIn SoftLabs, Chittoor, AP, India.*

**Abstract: -** *This research work brings out a novel equation for photo electric effect, which doesn't involve the mass and velocity of the electron emitted due to the incident photon, rather it involves the frequency of motion of the ejected electron, which is under motion.*

**Key Words: -** *Electron, Photon, Photo Electric Effect, Frequency, Wave Length, Frequency Based Kinetic Energy Equation.*

---

Date of Submission: 21-05-2023 Date of Acceptance: 12-06-2023

---

## I. Introduction

Solar cells are famous these days as one of the sources of green energy. The physics we know, behind the working of these solar cells is in fact older than a century. In the year 1905 the famous scientist Albert Einstein explained with his equation the working principle behind the solar cells and the related kind of electron emission or electricity production. In fact, the emission of the electrons due to the photons colliding with certain kinds of atoms is well known as the photo electric effect [Ref. 1].

When a photon strikes an atom of certain kinds of materials, then the atom, in fact the outer electron of it absorbs the photon and due to this its energy increases and now the electron can overcome the attraction of its parent nucleus and thus it comes out of the atom with certain energy, more specifically certain kinetic energy. Although this process had been observed by the scientists even long before Einstein, no one was able to explain the physics involved in this process accurately. Almost a century back Einstein explained it by the equation he had discovered, which in fact fetched him Nobel Prize in Physics. His equation is given in the next section as the equation ***eq. 1***.

Till now, there is no equation alternative to the equation of Einstein to explain the photo-electric effect. But, in this research work an alternative equation has been discovered which gives the frequency of the electron ejected due to the photo electric effect, unlike the kinetic energy of the electron as given by the Einstein's equation. This novel equation finds a relationship between the frequencies of all the three different energies involved in the photo electron emission process as explained in detail in the next section.

## II. Frequency Based Photo Electric Equation

When a photon of certain frequency touches an atom of certain type of materials, the incident photon knocks out an electron from the atom it hits and this electron comes out from its parent atom with certain velocity and hence, with certain kinetic energy. Different materials require different frequencies of photons for this to happen. This process is known as the ***photo electric effect*** and it has been known to the scientific community for a long time but, Physics behind it had not been explained for a long time, specifically until the starting of the twentieth century.

The following figure, fig. A represents the above concepts in a schematic diagram. In this figure, the bottom dark straight line represents the material on which the ***photon*** strikes, due to this impact an electron ($e^-$) from an atom of the material will come out from its parent atom with certain velocity and hence, with certain kinetic energy (K. E).

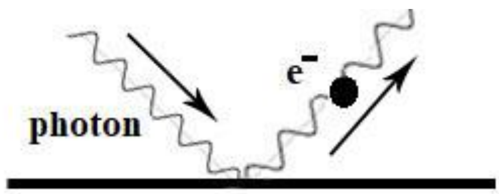


**Fig. A – The Photo Electric Effect**

One of the greatest physicists of all time, Albert Einstein, had discovered an equation to explain the Photo Electric Effect, which in fact fetched him the Nobel Prize in Physics. Although he is famous as a relativist, he didn't get the Nobel Prize for his theory of relativity but, for (this) his theory and the corresponding equation on the Photo Electric Effect. His famous *photoelectric effect equation* is given below [Ref. 2].

$$(m.\ v.\ v)\ /\ 2 = E^1 - E0 \qquad \textbf{Eq. 1}$$

Where, $E^1$ – is the energy of the incident beam of light ray (Photon), E0 - is the minimum energy required to remove the electron from the atom, the threshold energy of the electron, m - is the mass of the electron and v - is the velocity of the ejected electron from the atom due to the incident photon.

Alternatively, the above equation could also be written as follows, by expanding its energy (E) terms using the Planck's energy equation, E = h. f;

$$(m.\ v.\ v)\ /\ 2 = h.\ f^1 - h.\ f0 \qquad \textbf{Eq. 1A}$$

In the above equation $f^1$ and f0 are the frequency of the incident photon and the threshold frequency of the electron respectively and h – is the Planck's constant.

This equation was discovered by Einstein in the year 1905 and since then there is no other equation to describe the Photo Electric Effect. But, here we will derive an alternative equation that doesn't require the velocity and mass of the electron ejected due to the Photon. Rather this novel equation involves only the frequencies of all the three energies involved in the above equation.

In order to derive this novel equation, we will use the recent equation discovered by Indian researcher, ***Mr. Bhargava Kotur***. He had discovered the equation for the kinetic energy of a particle under uniform motion with a defined frequency of motion. His ***frequency based kinetic energy equation*** [Ref. 3] doesn't involve mass and velocity of the body or particle under motion in order to find the kinetic energy, rather it takes into account only the frequency of the body or particle under motion. His novel equation, the ***frequency based kinetic energy equation*** is given below. Here, in this equation, K. E – stands for the kinetic energy of the body or particle under motion, h – is the famous Planck's constant and f - is the frequency of the body or particle under uniform motion.

$$K.\ E = (h.\ f)\ /\ 2 \qquad \textbf{Eq. 2}$$

For the derivation and full details on this novel ***frequency based kinetic energy equation***, the readers are advised to check the original research work [Ref. 3] recently published by ***Mr. Bhargava Kotur***. Now, the equation ***eq. 1*** could be rewritten as follows;

$$K.\ E = E^1 - E0 \qquad \textbf{Eq. 3}$$

This is because; the left hand side of the eq. 1 is nothing but, the ***kinetic energy*** [Ref. 4] of the body or particle under uniform motion and the kinetic energy is given by the following famous equation, where m – is the mass of the body or particle under motion with uniform velocity, v.

$$K.\ E = (m.\ v.\ v)\ /\ 2$$

Now, by substituting the equation eq. 2 in the equation eq. 3 for the kinetic energy (K. E), we get the following equation;

$$(h.\ f)\ /\ 2 = E^1 - E0 \qquad \textbf{Eq. 4}$$

Note that the above equation is a novel equation for the photo electric effect, which gives or predicts the kinetic energy of the outgoing electron based upon its frequency of motion, "f". This is possible because of the de Broglie's prediction that the particles under motion will move not in straight lines but, they will move like waves. This concept is known as the *matter waves* in the modern physics. De Broglie had given the equation to predict the wave length of the particles moving under uniform motion, which is now known on his name as the de Broglie's wave equation [Ref. 5]. That equation is not mentioned here as it is not required in this work. However, the derivation of the *frequency based kinetic energy* equation, given earlier as eq. 2, in fact is based upon the de Broglie's wave equation.

So, the electron that comes out from the atom due to the incident photon, moves not in a straight line but, it moves like a wave with a defined frequency, f, which is predicted by the just above equation, eq. 4.

The energy (E) in the above equation is represented by the famous equation [Ref. 6] of Max Planck as follows, where h - is the ***Planck's constant*** and f – is the frequency of the photon, the ray of electromagnetic energy.

$$\mathbf{E = h.\ f}$$

From the two equations present immediately above it follows that;

$$\mathbf{(h.\ f) / 2 = h.\ f^1 - h.\ f\ 0} \qquad \textbf{Eq. 5}$$

The above equation yields the following equation, after eliminating the "h" from it.

$$\mathbf{f = 2\ (f^1 - f\ 0)} \qquad \textbf{Eq. 6}$$

This is the novel equation for photo electric effect, we finally derived and discovered. It is interesting to see that this equation doesn't contain the mass and velocity of the electron ejected in the process, rather it contains only the frequencies of all the three energies involved in the process. The frequency of motion of the ejected electron (f), the frequency of the incident photon ($f^1$), the minimum frequency (f0) of the energy required to eject the electron from its orbital in its parent atom, known as the ***threshold energy*** of the electron. Note that the frequency of motion of the electron is a measure of its kinetic energy as defined by the equation, *eq. 2*, mentioned earlier.

The above equation implies the following three cases;

**Case One: $f^1 < f0$**

It implies that the frequency $f^1$ - of the incident photon is less than the threshold frequency, f0 of the electron in its parent atom. In this case, due to the less energy of the incident photon, electron can't come out of the atom. Hence, this will not lead to the emission of the photoelectron.

**Case Two: $f^1 = f0$**

In this case, the frequency $f^1$ - of the incident photon is just equal to the threshold frequency f0 of the electron in its parent atom. In this case, the incident photon just has the energy required to kick the electron out of its orbital in its parent atom. In this case, the electron will come out of the atom, but it has no kinetic energy to move away from the atom. Due to this, the electron will stay in the neighborhood of its parent atom, as it lacks energy and can't move away.

**Case Three: $f^1 > f0$**

Here, the energy of the incident photon is more than the threshold energy of the electron in its parent atom. In other words, the incident photon has higher frequency than the threshold frequency required to remove the electron from its parent atom. Hence, in this case the electron will come out from its parent atom with certain kinetic energy and moves away.

The incident photon frequency ($f^1$) should be greater than the threshold frequency (f0) of the electron for the electron to have some kinetic energy and hence, some frequency (f) of motion. Otherwise, the electron can't move away from the vicinity of its parent atom. Hence, ***for the electron to have some measurable frequency (f) of motion, the just above given inequality should hold true***.

For any given material (f0 - becomes fixed), as the frequency of the incident photon ($f^1$) keeps on increasing, the kinetic energy of the ejected electron too keeps on increasing correspondingly and hence, its frequency of motion as well keeps on increasing. So, it implies that, for a given material, ***more the frequency of the incident photon, more will be the frequency of motion of the ejected electron*** as well and consequently the electron has more velocity and could travel a long distance due to its more kinetic energy. Here, it should be noted that for a particle or body under uniform motion, the frequency of motion and kinetic energy are directly proportional to one another; if one of these increases, the other too will increase correspondingly. This fact is directly implied by the equation eq. 2 mentioned already.

If we are interested to find the frequency of the ejected electron then we could use the above discovered equation directly in order to find it. This is the novel equation for photo-electric effect, in fact an alternative equation for photo-electric effect based exclusively upon all the frequencies of all the different energies involved in the photo-electron emission process.

**Efficiency:**

It is interesting to note that the novel equation for photoelectric effect, ***eq.6*** is in fact efficient compared to the Einstein's equation ***eq.1***, in the sense that the novel equation has only three terms (*factors, elements*), all the three different frequencies involved in the photoelectric emission process whereas the Einstein's equation has five terms (*factors, elements*) in total, if frequencies are considered (*see the eq. 1A*) and four terms (*factors, elements*) if the energies are taken into account (*see the eq. 1*).

That is if we want to know the velocity of the electron emitted in the photoelectric emission process, then the Einstein's equation eq. 1A requires these four values; the mass of the electron, the Planck's constant, the frequency of the incident photon, the threshold frequency of the electron. Otherwise, in order to use the equation eq. 1, we should know these three values; the mass of the electron, the energy of the incident photon and the threshold energy of the electron in the atom concerned. But, in order to find the frequency of the electron emitted in the photoelectric emission process, using the novel equation eq. 6, we need only two values; the frequency of the incident photon and the threshold frequency of the electron in the atom concerned.

Hence, from this perspective the novel equation seems better compared to the Einstein's photoelectric equation; from the point of the number of terms (*factors, elements*) involved in the respective equations. But, of course, these two different equations are not aimed to find the same thing; these two are focusing on two different *things* of the ejected electron. The Einstein's equation eq. 1 is concerned with the velocity of the photoelectron, whereas the novel equation eq. 6 is concerned with the frequency of the photoelectron ejected in the process.

Nonetheless, both of these equations are concerned with explaining the process of photoelectric effect and naturally, the equation that explains it with less number of terms (*factors, elements*) is in fact relatively more efficient; hence, the claim.

## III. Conclusions

A novel equation for photo-electric effect has been discovered in this research work, which doesn't involve the mass and velocity of the ejected electron rather, it involves all the three different frequencies of the three different energies involved in the process; the frequency of motion of the electron ejected due to the incident photon in the photo-electric effect along with the frequency of the incident photon and the threshold frequency of the electron in the atom concerned.

## References

**Note: - Except for reference [3], for others any standard book on Physics will help, including these;**


[1]. Physics – Part II – By Halliday & Resnick – Wiley Eastern Limited, P.1179;

[2]. Advanced Level Physics - By M. Nelkon & P. Parker - Heinemann Educational Books Ltd., London, (1987), P.847.

[3]. Bhargava R. Kotur. "Kinetic Energy Of A Particle Independent Of Its Mass & Velocity." IOSR Journal Of Applied Physics (IOSR-JAP), 15(1), 2023, Pp. 34-41, DOI: 10.9790/4861-1501013441

[4]. Physics – Part I – By Resnick & Halliday – Wiley Eastern Limited, P.142;

[5]. University Physics – By Mark Zeamansky Etc., - Addison Wesley Publishing, P.1201;

[6]. University Physics - By Mark Zeamansky Etc., - Addison Wesley Publishing, P.159;


Bhargava R. Kotur, "Novel Equation for Photo-Electric Effect", *IOSR Journal of Applied Physics (IOSR-JAP)*, 15(4), 2023, pp. 01-04.