

Drawbacks of “Albert Einstein’s photoelectric effect”

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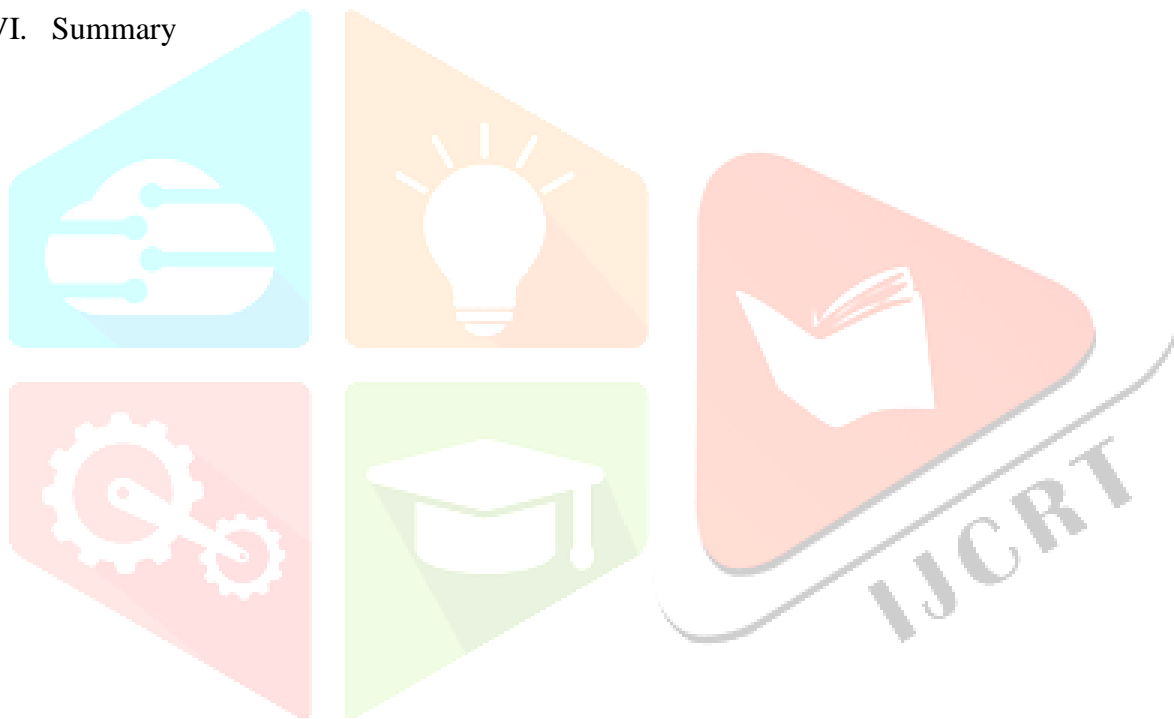
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(Article is obtained from Department of Physics IIT Chennai-600036. Annexure is annexed with it and marked as --- A).
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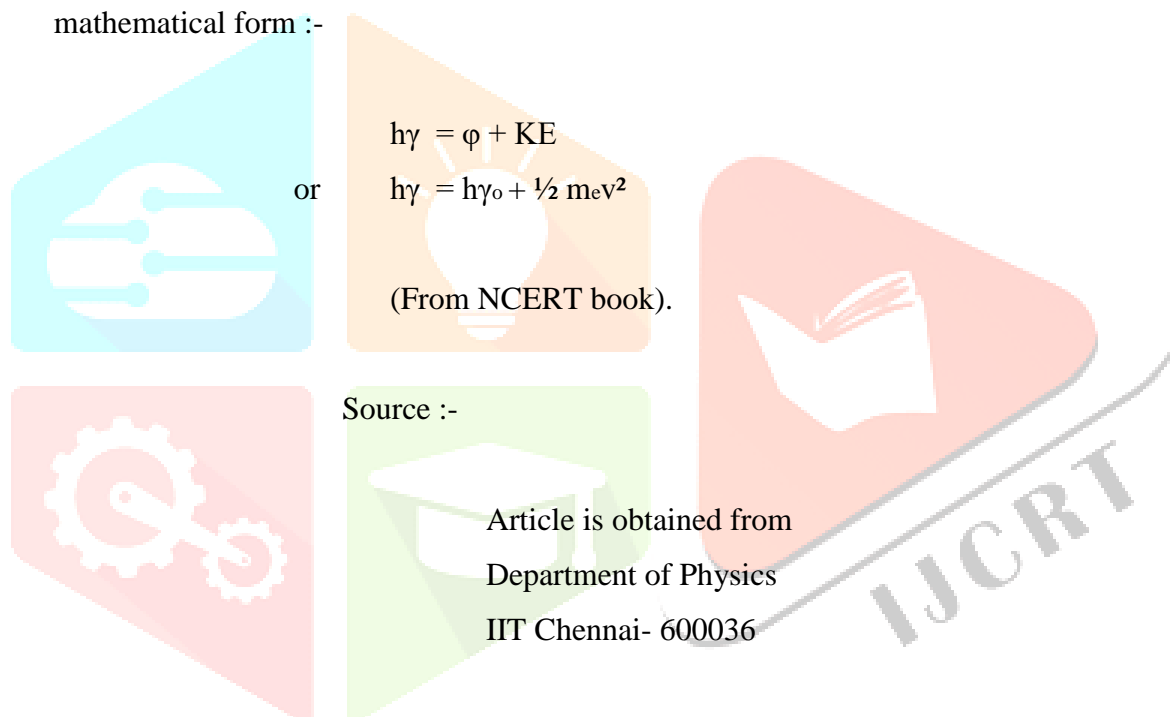


(I) Brief explanation of Einstein's Photoelectric Equation :-

Wrote Einstein " According to the assumption considered here, when a light ray starting from a point is propagated, the energy is not continuously distributed an ever increasing volume, but it consists of a finite number of energy quanta, localized in space, which move without being divided and which can be absorbed or emitted as a whole.

In essence, Einstein proposed that the incident electromagnetic energy is absorbed as a corpuscle of energy $h\nu$ by the metal plate. As a result, an electron is ejected from the plate. A part of energy absorbed goes to overcome the "work function" ϕ and the residual energy is carried by the ejected electron as its kinetic energy.

Einstein expressed the conservation of energy in the following mathematical form :-



or

$$h\nu = \phi + KE$$

$$h\nu = h\nu_0 + \frac{1}{2} m_e v^2$$

(From NCERT book).

Source :-

Article is obtained from
Department of Physics
IIT Chennai- 600036

(Annexure is annexed with it and marked as – A)

(II) Drawbacks of the photoelectric equation/explanation of Einstein :-

- 1) Quantisation of photon is not done.
- 2) Every photon having the energy $h\nu$ is mentioned.
- 3) Phases of incident photon is not defined.
- 4) Types of collision/interaction between photon and the electron of metal plate is not defined.

5) 'A part of energy absorbed goes to overcome the "work function" ϕ and the residual energy is carried by the ejected electron as its kinetic energy'. Is mentioned means more than one photon involved in this process.

6) So it becomes a time lagging process.

7) Breaking of photon is mentioned in the equation.

$$h\nu = \phi + KE$$

8) Ejection of photoelectron is because of the change in the frequency of photon is mentioned.

$$h\nu = h\nu_0 + \frac{1}{2} m_e v^2$$

when a light/photon enters from one medium to another medium frequency of light/photon remains unchanged.

9) Two different types of frequency (ν for incident photon and ν_0 for an electron of metal plate) is used in the equation.

10) So it does not follow up the arrow of time.

11) It does not follow up the law of conservation of energy

12) It does not follow up heisenberg's uncertainty principle.

13) It completely violets the law of physics (the unification of physics), the theory of relativity and quantum mechanics combinedly.

(III) Important points of our thesis :-

1) Quantanisation of photon and the electron of the metal plate is done.

2) Incident photon and the electron of the metal plate must be in phase.

3) There is an elastic collision between incident photon and the electron of metal plate is done.

4) Reaction proceeds through the transition state.

5) If energy of the incident photon at this state is sufficient enough to overcome the "work function ϕ of the metal plate, due to quantum fluctuation or Heisenberg's uncertainty, there is an ejection of photoelectron from the metal plate.

6) The kinetic energy of this electron is $\frac{1}{2} m_e v^2$

7) Since reaction proceeds through the transition state so it is an instantaneous process.

8) Then photon as a whole is separated form the metal plate because it is not sensitive to the scale (does not follow up the Pauli's exclusion principle)

9) Uniform type of frequency is used for photon and the electron of metal plate.

10) So it follow up the arrow of time.

- 11) It follow up the law of physics (the unification of physics), the theory of relativity and quantum mechanics combinedly.
- 12) Our equation is dimensionally correct & follow up the law of conservation of energy. Independent of the frame of reference.
- 13) Only one photon is involve without being breaking for ejection of the electron from the metal plate, which is absorbed and emitted as a whole.
- 14) If the energy of incident photon is greater than ϕ of the electron of metal plate, it ejects out with energy $\frac{1}{2} m_e v^2$.
- 15) If the energy of incident photon and the electron of metal plate are same it may just eject out because of quantum fluctuation. This electron has not any bonding with the original atom, but of course it is not an free electron, as it is still in the vicinity of the concern atom attached by a secondary force of attraction.

(IV) Derivation of correct photoelectric equation :-

Two photon waves in phase are approaching the crystal and after reflecton, the difference in distance traveled by the two rays (i.e. path difference) must equal an integral number of wavelength $n\lambda$, for constructive interference.

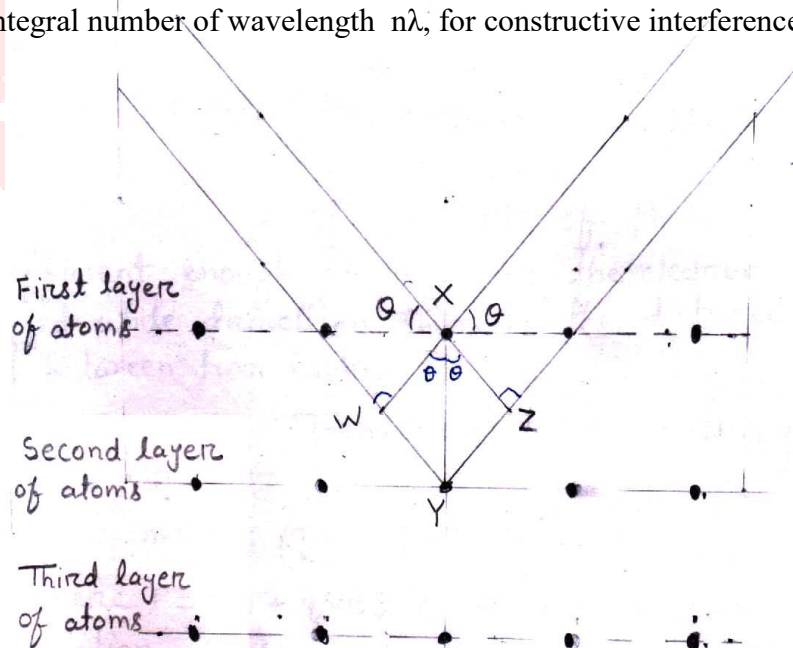


Fig :- The diffraction of two waves of X-rays by the regularly spaced atoms in a crystal.

The path difference = WY + YZ
 = XY Sinθ + XY Sinθ
 = 2XY Sinθ
 = 2d Sinθ

Where d is the distance between two planes

$$N\lambda = 2d \text{ Sin}\theta \text{ -----(1)}$$

If corpuscle of photon is sufficient enough to overcome the electromagnetic field while traveling through the distance d between two layers.

Then from work- energy theorm :-

$$\frac{1}{2} mv^2 = (qE + qvB \text{ Sin}\theta) d$$

(Where F = qE + qvB Sinθ, known as Lorenz’s equation of force in the electromagnetic field)

According to Einstein if we develop the expression for the kinetic energy in the form of a series, then we obtain $mc^2, \frac{1}{2} mv^2, \frac{3}{2} mv^2, \dots$

$$\begin{aligned} mc^2 - 2qEd &= 2qvB \text{ Sin}\theta \cdot d \\ &= qvB (2d \text{ Sin}\theta) \\ &= qvBn\lambda \end{aligned}$$

(From eq (1))

This is the energy to overcome the magnetic field while traveling through the distance “d”

Then from the law of conservation of energy

$$\begin{aligned} E_T &= qvBn\lambda \\ &= qvBn \left(\frac{h}{mv} \right) \\ &= nh \left(\frac{qB}{m} \right) \\ &= n\theta h\nu \end{aligned}$$

Hence, $E_T = n\theta h\nu$

For black body zero spin field should be created (by Linde and Stephen Hawking) So 'θ' is omitted from the equation

Hence for black body

$$E = nh\nu$$

Where n = Principal quantum number

$$= 1,2,3,\dots\text{etc.}$$

However Max planck was unable to explain why energy of photon is integral multiple of $h\nu$. For ex $h\nu, 2h\nu, 3h\nu, \dots\text{etc.}$ (from NCERT Book)

The path of light rays in the event horizon had always to be moving parallel to, or away from, each other.

Zero spin field means that in the empty space (event horizon) the field cannot be fixed at exactly zero. It would have both a precise value (zero) and precise rate of change (zero). So it contains certain minimum amount of uncertainty or quantum fluctuations in the value of the field, these fluctuations appears as a of particles of light or gravity (Dirac) that appears together at some time.

In the year 1956 Chien –Shiung Wu, lining up the nuclei of radioactive atoms in a magnetic field, so that they were all spinning in the same direction and showed that the electron were given off more in one direction than another.

Heisenberg's uncertainty or quantum fluctuation is the root cause of the photoelectric effect.

Black body radiates energy discontinuously in a small packet called quanta (Sing – quantum) which may be an integral multiple of $h\nu$ (i.e. $nh\nu$), the energy is not continuously distributed an ever increasing volume (when we combine theory of relativity with quantum mechanics, it can be shown that our universe is energetically finite – Stephen Hawking), but it consists of a finite number of energy quanta, localized in space which move without being divided and which can be absorbed or emitted as a whole (because of these energy photon is not sensitive to scale i.e. does not follow up the Puli's exclusion principle)

Here

θ = Azimuthal quantum number or Angular momentum quantum number

$\omega = \frac{qB}{m}$ = The Angular speed of rotation

$\lambda = h/mv =$ de Broglie wavelength of wave- particle duality concept

Correct forms of the photoelectric equation should be :-

$$nh\nu = \phi + \frac{1}{2} m_e v^2$$

or $nh\nu = n'\theta h\nu + \frac{1}{2} m_e v^2$

Here

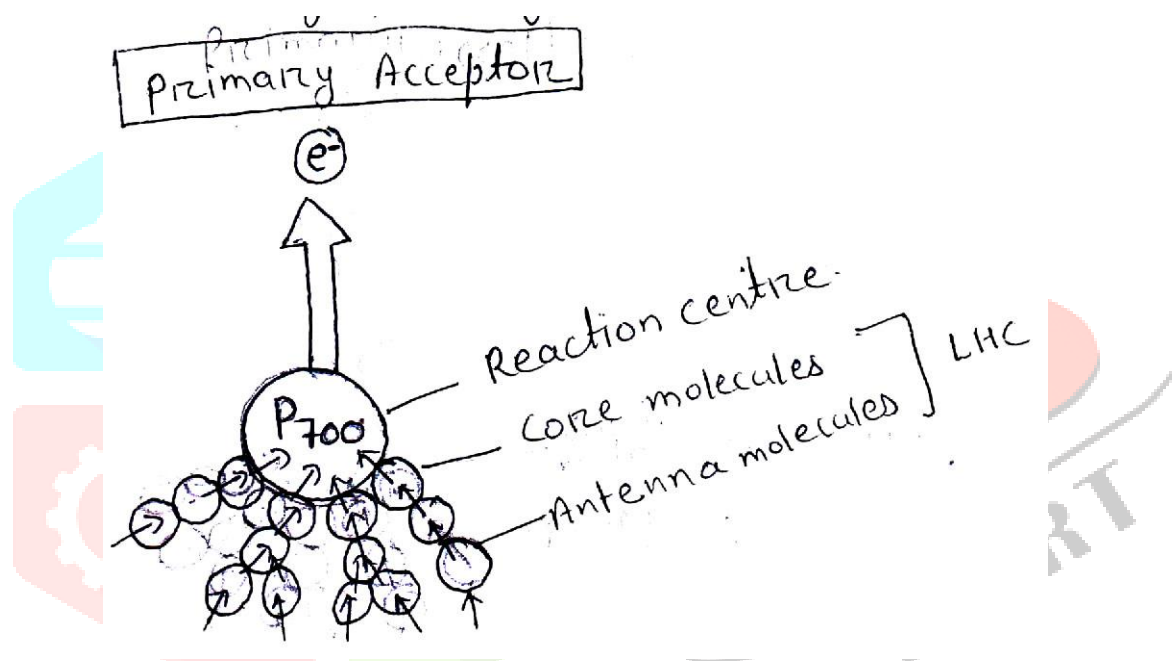
$nh\nu$ = Energy of an incident photon

$n'\theta h\nu$ = Work function of the electron of metal plate

$\frac{1}{2} m_e v^2$ = kinetic energy of the ejected electron.

(V) For example :-

Ejection of photoelectron from a photosynthetic unit in a light phase reaction of photosynthesis



Where LHC = Light harvesting complex

Harvesting of Light by a photosynthetic unit. Note that the radiation energy absorbed by antenna molecules is transferred to the core molecules through electron spin resonance.

(VI)

Summary

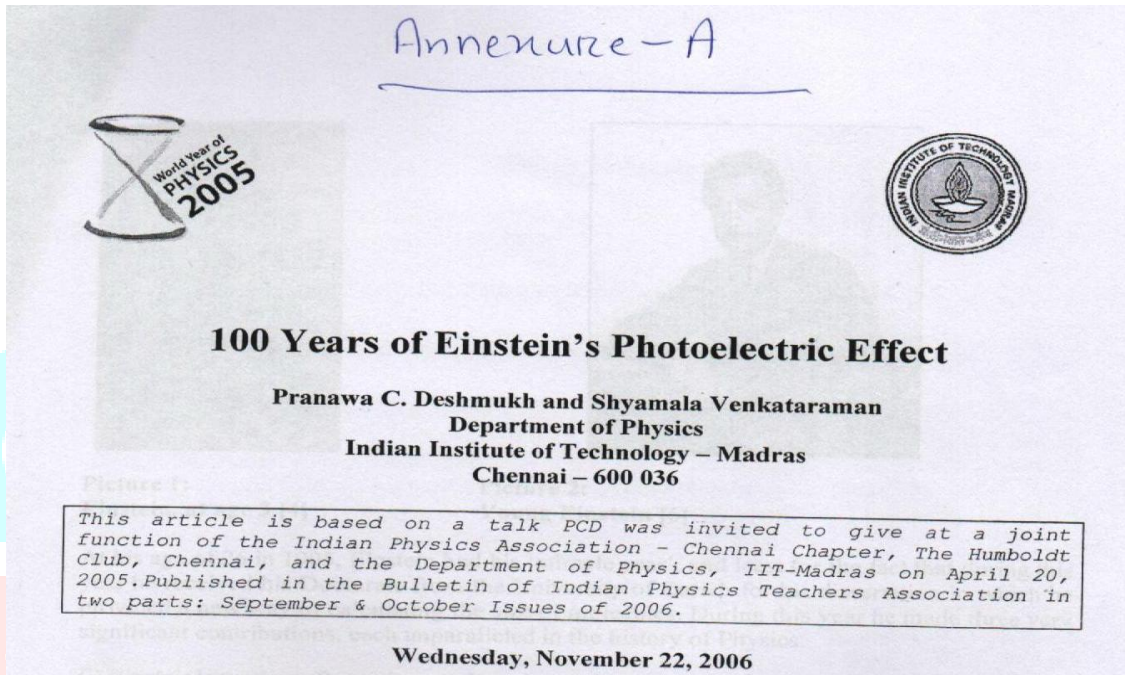
Black body radiates energy discontinuously in a small packet called quanta (sing quantum) which may be an integral multiple of $h\nu$ (i.e. $nh\nu$), the energy is not continuously distributed an ever increasing volume, but it consists of a finite number of energy quanta localised in space, which move without being divided and which can be absorbed or emitted as a whole.

So correct form of the photoelectric equation should be

$$nh\nu = \phi + \frac{1}{2} m_e v^2$$

or $nh\nu = n'\theta h\nu + \frac{1}{2} m_e v^2$

Our equation is dimensionally correct and follow up the law of conservation of energy independent of the frame of reference. It obeys the law of physics (the unification of Physics), the theory of relativity and quantum mechanics combinedly. Quantisation of particle of photon / virtual / real particle is done. Same type of frequency is used in the equation so that its characteristics remains unchanged. So that it follow up the arrow of time it is an instantaneous spontaneous process. Heisenberg's uncertainty or quantum fluctuation is the root cause of the photoelectric effect in the nature



Until Einstein wrote this paper, it was assumed that electromagnetic radiation traveled as waves. Einstein considered the quantization of light into packets of energy called quanta in the context of propagation of EM energy. Wrote Einstein: *"According to the assumption considered here, when a light ray starting from a point is propagated, the energy is not continuously distributed over an ever increasing volume, but it consists of a finite number of energy quanta, localized in space, which move without being divided and which can be absorbed or emitted only as a whole"*.



Picture 5:
Albert Einstein [16]

The Photo-Electric-Effect is named after Einstein, not Lenard.

Lenard never forgave Einstein for this!

In essence, Einstein proposed that the incident electromagnetic energy is absorbed as a corpuscle of energy $h\nu$ by the metal plate. As a result, an electron is ejected from the plate. A part of the energy absorbed goes to overcome the 'work function', ϕ and the residual energy

is carried by the ejected electron as its kinetic energy. Essentially, Einstein expressed the conservation of energy in the following mathematical form:

$$h\nu = \phi + \text{K.E.} \quad (1)$$

