2.4. Einstein's postulates and interpretation

As we have seen the observations made by Lenard cannot be explained based on classical electromagnetic wave predictions.

Einstein framed a number of postulates about the nature of light and the interaction of light with matter. He suggested that electromagnetic radiation is quantized.

(1) Light of frequency f consists of discrete energy quanta. (also called photons)

Each quanta has the energy $E = hf$

where h is the Planck's constant

$$h = 6.63 \times 10^{-34} \text{ Js}$$

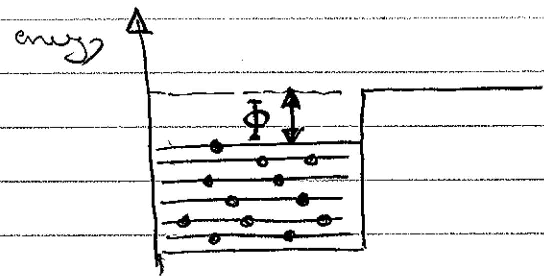
(2) One light quantum is absorbed (interacts with)

- with one electron in metal
- entirely (not in halves or other fractions)
- and instanteounesly

Let's ✓ and how Einstein's postulates apply to the interpretation of the photoelectric effect.

- Energy conservation → Frequency dependence.

Let's go back to our energy diagram for electrons in metal



There is a work function ϕ = energy needed to free most loosely bound electron

Energy conservation:

$$KE = E_{light} - \Phi = hf - \phi$$

↑ kinetic energy of electron

⇒ Kinetic energy depends linearly on frequency

and there exist a threshold frequency

$$0 = hf_0 - \Phi \Rightarrow f_0 = \frac{\phi}{h}$$

below which no electrons are set free

and this threshold frequency depends on metal via work function Φ

> There is a distribution of kinetic energies since different photoelectrons require different amount of energy.

- Intensity considerations

The maximum kinetic energy or the stopping potential is given by

$$KE = hf - \phi = eV_{stop}$$

$$\Rightarrow V_{stop} = \frac{hf - \phi}{e}$$

These are <u>independent</u> of intensity.

Let's determine intensity (according to Einstein)

$$\text{Intensity} = \frac{\text{Power}}{\text{Beam area}}$$

$$= \frac{\text{Energy}}{(\text{Time})(\text{Beam area})}$$

$$= \frac{Nhf}{(\text{Time})(\text{Beam area})}$$: N : number of photons in beam

Since <u>one</u> photon interacts with <u>one</u> electron, we see

current ~ # ejected electrons

~ # absorbed photons ~ Intensity

=> Current ~ Intensity

- Time considerations

Each energy quantum (photon) is instantaneously absorbed entirely by one electron

=> There is no time delay between emission of electrons (current) and moment when light is applied.