Radiation Interactions: The operation of any radiation detector basically depends on the manner in which the radiation to be detected interacts with the material of the detector itself. An understanding of the response of a specific type of detector must therefore be based on a familiarity with the fundamental mechanisms by which radiations interact and lose their energy in matter. The radiation can be classified in order to the charge and mass to the: Heavy charged particles, light charged particles, gamma ray and neutrons.

Interaction of heavy charged particles with matter:

Heavy charged particles, such as the alpha particle and protons, interact with matter primarily through coulomb forces between their positive charge and the negative charge of the orbital electrons within the absorber atoms. Although interactions of the particle with nuclei (as in Rutherford scattering or alpha-particle induced reactions) are also possible.

Upon entering any absorbing medium, the charged particle immediately interacts simultaneously with many electrons. In any one such encounter, the electron feels an impulse from the attractive coulomb force as the particle passes its vicinity. Depending on the proximity of the encounter, this impulse may be sufficient either to raise the electron to a higher-lying shell within the absorber atom (excitation) or to remove completely the electron from the atom (ionization).

The linear stopping power S for charged particles in a given absorber is simply defined as the differential energy loss for that particle within the material divided by the corresponding differential path length:

$$S = - dE / dx$$

As for the distance that the particle can travel inside the material, starting from the source until its kinetic energy becomes zero, it is known as the range coefficient (R). The path of the particle inside the material takes the form of a straight line until it approaches its end. The range can be calculated by the following equation:

$$R = \int_0^R dx = \int (-\frac{dE}{dx})^{-1} = \int_0^E \frac{dE}{S(E)}$$

Interaction of light particles (electrons) with matter

Light charged particles such as the electron and the positron are similar in their interaction as heavy charged particles in terms of the Coulomb effect, but because of the convergence of their mass with the orbital electron, so their path inside the matter means a number of deviations. Therefore, the interaction of light particles with matter is classified into two types: the Coulomb interaction and the radiation interaction.

- **Coulomb interaction**: is the loss of energy by inelastic collisions with an orbital electron, such as when heavy particles interact with matter. When energy is transmitted, it either excited or ionized. The stopping power can be calculated through the equation that developed by Mott through the equation:

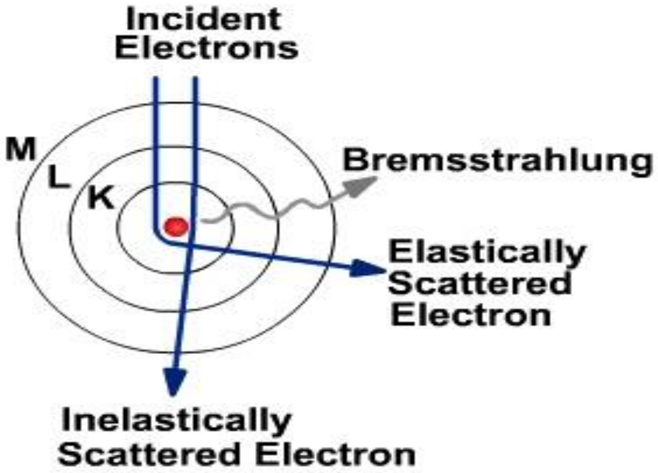
$$S = -\left(\frac{dE}{dX}\right)_c$$

- **Radiological interaction**: This type of interaction distinguishes the light particles, and energy is lost through radiation is called stopping radiation. High-energy electrons may reach a distance close to the inner orbit of the atom (K) as a result of the effect of the Coulomb attraction between the electron and the nucleus. When the electron approaches a distance close to the potential of the nucleus, it deviates from its path, and this deviation leads to the emission of photons whose total energy is part of the energy of the incoming electron. To explain this, the nucleus tries to stop the electron by the Coulomb force, but the electron suddenly gets acceleration as a result of the electromagnetic field of the nucleus, this process is accompanied by the emission of rays is called (Bremsstrahlung). The stopping energy can be calculated by the following equation:

$$S = -\left(\frac{dE}{dX}\right)_r$$

The total stopping energy can be expressed as:

$$S = \left(\frac{dE}{dx}\right)_{total} = \left(\frac{dE}{dx}\right)_c + \left(\frac{dE}{dx}\right)_r$$



Interaction of neutrons with matter

Neutrons are neutral in charge, so they do not interact with orbital electrons at all, and thus reach the nucleus, cutting the Coulomb barrier without hindrance. The fast neutrons collide with the nuclei of the target material, thus forming the combined nucleus, which is in the maximum excited state. The combined nucleus is eliminated from excitation by one of the following decay channels:

- Elastic scattering channel
- Inelastic scattering channel
- Interaction (*n*, *p*) channel.
- Interaction (*n*, *2n*) channel.
- Interaction (n, γ) channel.

➢ **Laws of Absorption:** When gamma or X-rays interact, the decrease in the intensity of the rays when they fall on a material is directly proportional to the intensity (*I*) and the thickness of the material (*Δx*), so:

$$\Delta I \alpha - I \Delta x$$

$$\Delta I = -\mu I \Delta x$$

Where (μ) is absorption coefficient of materials.

$$-\frac{dI}{dx} = \mu I$$

$$\int_{I_o}^{I} \frac{dI}{I} = -\mu \int_{0}^{x} dx$$

$$Ln\ \frac{I}{I_o} = -\mu x$$

$$\frac{I}{I_o} = e^{-\mu x}$$

$$I = I_o e^{-\mu x}$$

Where (I) is the intensity of the rays after passing through the thickness (x) of the material.

- Half – thickness: The thickness of the absorbent material that reduces the number of penetrating particles to half of its original number and is denoted by the symbol $x_{1/2}$

$$I = \frac{I_o}{2} \quad \rightarrow \quad x = x_{1/2}$$

$$\frac{I_o}{2} = I_o e^{-\mu x_{1/2}}$$

$\frac{1}{2} = e^{-\mu x_{1/2}}$ So that: ln (1/2) = - $\mu\, x_{1/2}$

$$\mu = \frac{0.693}{x_{1/2}}$$

- Hint: Each material has its own absorption coefficient (μ); there are two types of absorption coefficient:

1. Linear absorption coefficient (μ_l) its unit m^{-1} ، cm^{-1}

2. Mass absorption coefficient (μ_m) It is the result of dividing the linear absorption coefficient by the density of the absorbent material, and is measured in units $\frac{cm^2}{g}$ ، $\frac{m^2}{Kg}$