International Journal for Multidisciplinary Research (IJFMR)
E-ISSN : 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Theoretical and Empirical Models High Energy Electrons and Positrons in Relativistic

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Abstract

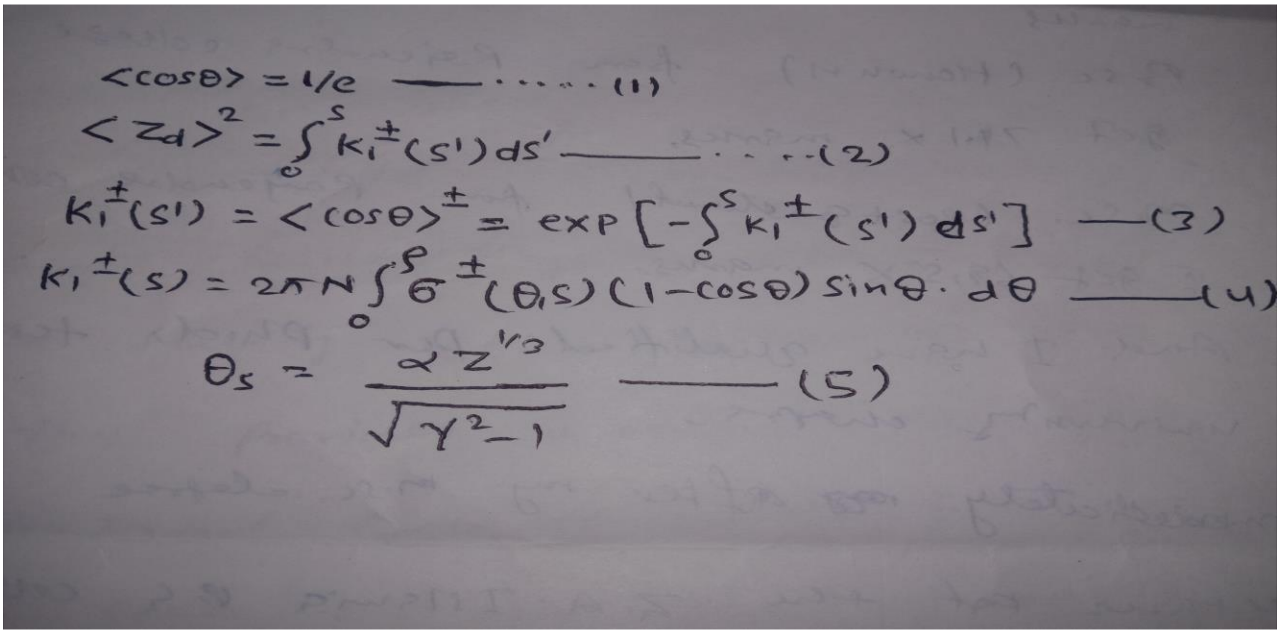
In recent theoretical study electrons or a positron penetrate through a target oil it interacts mainly in two ways, viz, slowing down process and elastic scattering. These two processes complete each other depending upon the electron a positron initial kinetic energy as well as atomic number of materials. Thus, it becomes very difficult to sketch theexact picture of preparation of these particles. A comparison of our evaluated cross-section with the available experimental data and other theoretical finding shows a reasonable agreement over the studiedenergy range. When electron or a Positron enters the materials the cross section for slowing down be in the majority over that for the elastic scattering begins to gain magnitude with decreasing energy of electron and positrons. Thus more and more the partical beam suffers divergence from the line of incidence. As these particles penetrate further, their initial kinetic energy, the cross- section for elastic scattering becomes very large. At this stage of diffusion sets in. In this condition for average cosine of multi scattering angular distributions becomes equal to 1/e and electron/ positrons target their initial direction of motion.

Monte Carlo method

The Monte Carlo method is a stochastic calculation method for problemwith no conclusive solutions. The Monte Carlo method provides a numerical solution to a problem that models objects interacting with other object or their environment connections. Problem due to the insolubility of electron and Positrons transport in a Material are solved by monte Carlo tThese techniques used knowledge of the probability distribution governing the particular interaction photons and electrons in material to simulated the random histories of individual particles. Toget result with high precision a large number of particle histories must be simulated. The relationship between shifted S^2, number of histories N and the timeT . S^2= constant, S^2T= constant.

As it can easily be seen from the above questions the number of histories N has to be increased by a component of 4 to decrease shifted S^2 by the factor of 2. This means that long calculations times are needed to get sufficient precision. Because of this duration Monte Carlo method is not widely used to clinical application. However, the use of monte Carlo techniques in radiation physics and radiation protection has been necessarily increase in the last few years. The increased use of Monte Carlo techniques can be attributed to the huge increase in computing power and increasing accessibility of many software tools. In 1954, Rohrlich and Carlson tried to determine theoretically the partical ranges of 0.102MeV to 2.04MeV electron andpositrons in aluminium and lead. for this they calculated almost part of range before difussin sets in by using Lewis theory of electron penetration to the extend of first moment endemic distribution. They termed this part of range as average penetration depth (Zd). This has said to correspond

to limiting thinkness where the original direction of the electron and positron beams is in point of fact lost. Mathematically this condition was defined as,
Where theta is the multiple scattrring angle. Overbearing the directionof incidence along Z-axis flowing Lewis the first momentum of expansion in depth of Positron or electrons with incident kinetic energy T is given by where superscript later + and - correspond to a Positron and electron respectively and S indicate the pass length corresponding to kinetic energy T and where, for appreciate K1^-(s) and K1^+ Rohlich and Carlson used relativistic Mott scattering cross sections and extensions by message for positions respectively because of use of this single elastic scattering cross sections and is extension by Messey for Positron respectively. Because of use of these single elastic scattering cross-sections the lowest limit to the integral mixed in equation (4) we set as, the William choice for scattering angle. The upper limit remained by infrequently neglecting and effect of finite size of nucleus for energy ~2.0MeV.



$$\langle \cos\theta \rangle = 1/e \quad \text{......(1)}$$

$$\langle Z_d \rangle^2 = \int_0^s K_1^{\pm}(s')\, ds' \quad \text{.....(2)}$$

$$K_1^{\pm}(s') = \langle \cos\theta \rangle^{\pm} = \exp\left[-\int_0^s K_1^{\pm}(s')\, ds'\right] \quad \text{(3)}$$

$$K_1^{\pm}(s) = 2\pi N \int_0^{\rho} \sigma^{\pm}(\theta, s)(1-\cos\theta)\sin\theta \cdot d\theta \quad \text{(4)}$$

$$\theta_s = \frac{\alpha Z^{1/3}}{\sqrt{\gamma^2 - 1}} \quad \text{(5)}$$

The distance traversed by an electron or a positron at any instant can always be expressed conveniently in term of kinetic energy . Since the Mott scattering cross-section expression up to first two terms is not accepted for high Z materials they used numerical summation approachof Bartlett and Wetson for these materials by using collision loss expression derived from Moller and Bhabha inelastic collision cross-sections for electrons and positrons respectively.
To simply the approximated the whole integral of equation (4), where a^+- and b^+- is constants.
These constants are different for positrons and electrons but are of thesame order of magnitude for Aluminium and Lead both. With the approximation they gave from equation (7) they nominal the average total energy Ed corresponding to the situation given by the equation (1)thus the average penetration 6 corresponding to Eo and Ed , the total initial and critical energies is given by , Then the remaining range of the electron and positron after the diffusion set was calculated by assuminguniform plane source of not actual electron placed at Z=Zd.

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$$K_1^{+}(\gamma) = \exp\left[-\int_{\gamma}^{\gamma_0} K_1^{\pm}(\gamma)\left(\left|\frac{d\gamma}{ds}\right|^{\pm}\right)^{-1} d\gamma\right] \quad (6)$$

Where $$K_1^{\pm}(\gamma) = 4\pi N Z^2 \gamma_e^2 \frac{\gamma^2}{(\gamma^2-1)^2}\left[\ln \frac{2\sqrt{\gamma^2-1}}{\alpha Z^{1/3}} - \frac{\gamma^2-1}{2\gamma^2} \mp \frac{\pi a Z\sqrt{\gamma^2-1}}{\gamma}\left(1-\frac{\alpha Z^{1/3}}{\sqrt{\gamma^2-1}}\right)\right] \quad (7)$$

$$K_1^{\pm}(\gamma) \left|\left(\frac{d\gamma}{ds}\right)^{-}\right|^{\pm} = \left[\frac{Z}{\gamma^2-1}\right]\left[2a^{\pm} + \frac{b^{\pm}}{\sqrt{\gamma^2-1}}\right] \quad (8)$$

$$K^{\pm}(\gamma_0,\gamma) = \langle \cos\theta \rangle^{\pm} = \left[\frac{G(\gamma_0)}{G(\gamma)}\right]^{\pm} \quad (9)$$

Where, $$G^{\pm}(\gamma) = \left[\frac{(\gamma+1)}{(\gamma-1)}\right] a^{\pm} Z e^{\frac{b^{\pm} Z}{\sqrt{\gamma^2-1}}} \quad (10)$$

$$Z_d^{\pm} = \int_{\gamma_d}^{\gamma_0} K_1^{\pm}(\gamma_0,\gamma)\left|\left(\frac{d\gamma}{ds}\right)^{\pm}\right|^{-1} d\gamma \quad (11)$$

The age of equation of diffusion theory viz
was used for this situation. Where F is the whole density of electros positrons and K^+- is given by equation (8). Uniform plane source of these particles at Z=Zd using equation (12) can be written as,
They calculation for R^-th using equation (13) in could not yield more than 50% and 90% of the partical range in the case of Lead and Aluminium respectively. However at energies greater than the rest mass energy of the electron where bramsstrahlung losses become suitable their disagreement with the practical range by taking into account several factors leading to inaccuracy in their
calculations:

$$\frac{\partial F}{\partial S} + \frac{1}{3K_1^{\pm}} \nabla^2 F = 0 \quad (12)$$

$$I(z) = I(Z_d)\left[1 - \exp\frac{Z - Z_d}{1.225\, \gamma_{av}^{\pm}}\right] \quad (13)$$

These factors are listed below :

1. The approximation method for solving the integral involved in equation (3) would amount an error in theoretical estimation of electron and positron ranges.

2. The use of collision energy loss expression only. Without taking into account the bramsstrahlung losses would also introduce error in calculations of these ranges. Such error would be more especially in the case of Lead for 2.0MeV electrons. In this case the bremsstrahlung energy losses are as much as 21 % of Total energy losses.

3. Although Rohrlich and Carlson have used theory of electron penetration due to Lewis, however they have ignored the fact that this theory is valid for infinite medium while they have made use for these theory in the context of semi Infinity medium. However one can notice disagreement between calculated ranges of electrons ever for energies below 0.5MeV in the case of Aluminium. Therefore inclusion of

bremsstrahlung losses (neglected by them) could not be required to improve the matter. Also an increment of 20% in 'Zd' value as a pointed out Matchnik and Tomlin would also not be able to confer the side arrangement for Pb since Zd, is much smaller than practical range and the agreement is as much as 50%. Thus this approach for calculating practical range of electrons theoretically, could not take account of measured practical range either in low or high Z absorbers or for energies for which these calculations were done.

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