Collisional Stopping Power for Electron and Positron in Beryllium, Titanium, Krypton, Germanium and Silver

Received :27/ 5 / 2018 **Accepted : 16 / 7 /2018**

Ahlam Habeeb Hussien

Ahlamh.alkhursan@uokufa.edu.iq

University of Kufa /College of Education for Girls

Abstract ***:***

In this study, the electronic stopping power of the falling electrons on the targeted elements (Beryllium, Titanium and Krypton) has been calculated at energy range of [0.01-1000] MeV and the results have been programmed with MATLAB program. The results were compared with the estar program and the results showed that they were well matched with the practical results.

In addition, the collisional stopping power of the falling positrons on the targeted element (Germanium and Silver) also has been studied at the same energy range. The results were compared with the results obtained by M.J. Berger and S.M. Seltzer and showed a good correlation from 0.06 to the end of the range that used.

Key words: The Collisional Stopping power, Estar programm, Electrons and Positrons

Introduction

The Stopping power $(-\frac{dE}{dx})$ of a medium for electron are important in a wide of applications involving energy depositing. In radiation physics , industry ,biology and medicine , it is often important to have simple but accurate information about loss energy of different media for energetic electrons Hence $(-\frac{dE}{dx})$ is defined as penetrating charged particle is the stopping power suffered by the particle per unit path length[1].

The loss energy evaluations are studied in two different ways : the First is to consider the interactions of incoming of the electrons and positrons with target electrons , which is called "collisional stopping power" while second is considered the fact that accelerated charged particles is radiated ,which is called radioactive loss energy or "Bremsstrahlung loss" which. The total loss energy for light charged particle can be written as following[2]

$$(-\frac{dE}{dx})_{tot} = (-\frac{dE}{dx})_{coll} + (-\frac{dE}{dx})_{rad}$$

…..(1)

Many studies on loss energy have been adopted , S. Ramesh Babu [3] calculated The stopping power of relativistic electron in thin aluminum foil has been The energies of the incident and transmitted internal conversion electrons have been measured using a Si(Li)detector coupled to 8K multichannel analyzer. S. K. Rathi et.al [4] present an semi-empirical relation for total loss energy keV in terms of total energy. for electron and positron , A fairly good agreement has been found between our simplified values for total loss energy of electron and positron for Carbon, Aluminum, Uranium and that of Berger and Seltzer calculated values. Mustafa Tufan et al. [5] studied the loss energy of some biological compounds of electron and positron across Power range from 100 eV to 1 GeV. total loss energy Obtained by "electronic collision" and beam braking of the target material and then Employing continual Slow rounding to calculate the particle path length that occurs in the Objective results are compared to available results. B.Yang , S. Fung [6] have measured the stopping power and energy straggling of monoenergetic positron in the energy range of 1-10 keV in carbon foil of different thicknesses. Their measured values were compared and the results showed that they were well matched with the theoretical values predicted by estar..

1-The Collisional Stopping Power

$$(-\frac{\mathbf{dE}}{\mathbf{dx}})_{\mathbf{coll}}$$

Electron loses its energy by ionization and excitation by the orbital electrons in the medium. mass stopping Power $(-\frac{dE}{dx})$ can be defined "as the rate of energy loss per unit path length of an electrons or positrons by excitation and ionization" which was known as "collisional energy loss"[7] on can written The mass collision stopping powers for electron [8]

$$(\frac{dE}{dx})_{coll}^{\mp} = \frac{4\pi r_e^2 m_e c^2 nz}{\beta^2 A}\left[\ln\frac{m_e c^2 \tau\sqrt{\tau+2}}{I\sqrt{2}} f(\beta)^{\mp}\right] \quad (2)$$

$$f(\beta)^- = \frac{1-\beta^2}{2}\left[1+\frac{\tau^2}{2} - (2\pi+1)\ln 2\right]$$

is used for electron$s$ (3)

$$f(\beta)^{+}=2\ln 2 - \frac{\beta^2}{12}\left[23+\frac{14}{(\tau+2)}+\frac{10}{(\tau+2)^2} + \frac{4}{(\tau+2)^3}\right] \quad \text{for positrons} \quad (4)$$

$$\beta = v/c$$

$$\tau = \frac{E}{m_e c^2}$$

r_e - radius of electron .

A - mass number of the target.

z - atomic number of the target.

I - the mean excitation potential of target.

n - the material electron density It can be written

$$n = N_A z\rho/AM_n$$

Where NA is Avogadro's number, ρ is the density of target and Mu is the molar mass constant

2-The Radiative stopping power $(-\frac{dE}{dx})_{rad}$

The deceleration of electrons near a nuclear field (due to columbic pulsion) is known as "beam braking or Bremsstrahlung". Bethe and Heitler obtained an approximate relation between the collisional stopping power and radiative stopping power by the relation[9]

$$-\frac{dE}{dx_{rad}} = -\frac{dE}{dx_{coll}}\left(\frac{zT}{800}\right) \qquad (5)$$

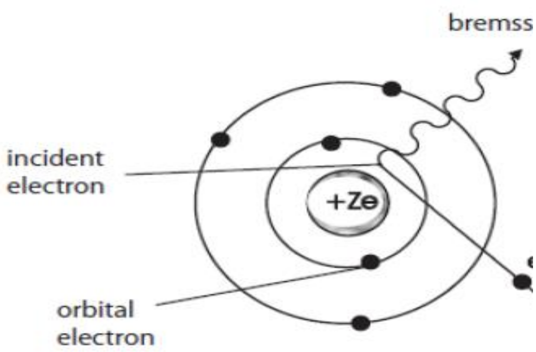

Fig.(1) Illustrates the Radiative stopping Power Mechanism which produces beam braking radiation

Where T is the energy of the incident positrons or electrons in MeV . By combining the equations (1) and (4) we get

$$-\frac{dE}{dx_{tot}} = -\frac{dE}{dx_{coll}}\left(1+\frac{zT}{800}\right) \quad (6)$$

Results and Discussion :-

Figures. (a) They represents the stopping power electrons when falling on the Beryllium element, equation (3) has been used after compensate it by equation (2) and the results were compared with the practical program estar[10],

shows that the results of the collision stopping power are slightly higher than the practical results of the ESTAR program with a slight difference, but they become close to the range of 0.04 and then continue to approach, but they become less until the end of the range that was used.

Figures. (b) They represents the stopping power electrons when falling on the Titanium element, equation (3) has been used after compensate it by equation (2) and the results were compared with the practical program estar. shows that they behave like a Beryllium element but they get closer to the practical results after 0.04 energy range

Figures. (c) They represents the stopping power electrons when falling on the Krypton element, equation (3) has been used after compensate it by equation (2) and the results were compared with the practical program estar. Note that the results of the collision stopping power are slightly divergent at the beginning and the end of the range of the estar program and the results converge only at the range of (0.06-1)MeV.

Figures (d, e) They represents the stopping power positrons when falling on the Germanium and Silver element, equation (4) has been used after compensate it by equation (2) and the results were compared with the practical results M.J. Berger and S.M. Seltzer[11], we noticed that they behave in the same way in which the atoms of the Beryllium behaved when sending electron projectiles against them, But the difference is in the values of the stopping power

The results are all shown in Table (1) and (2)

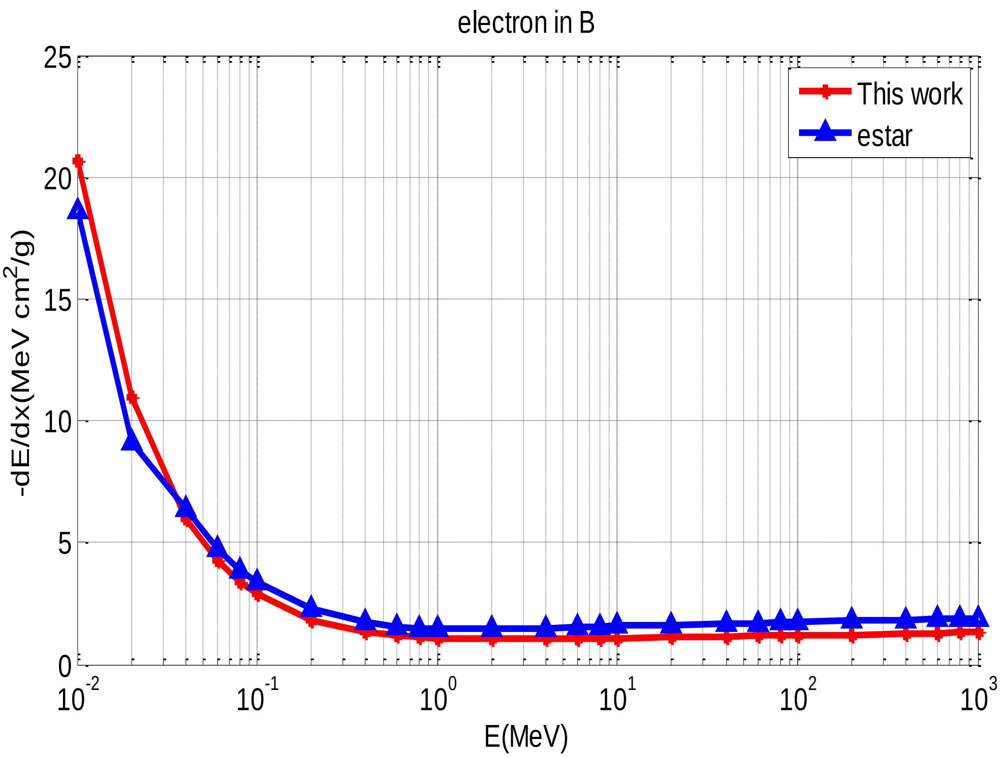

Fig.(a) the collisional stopping power for electron in (*Beryllium*)

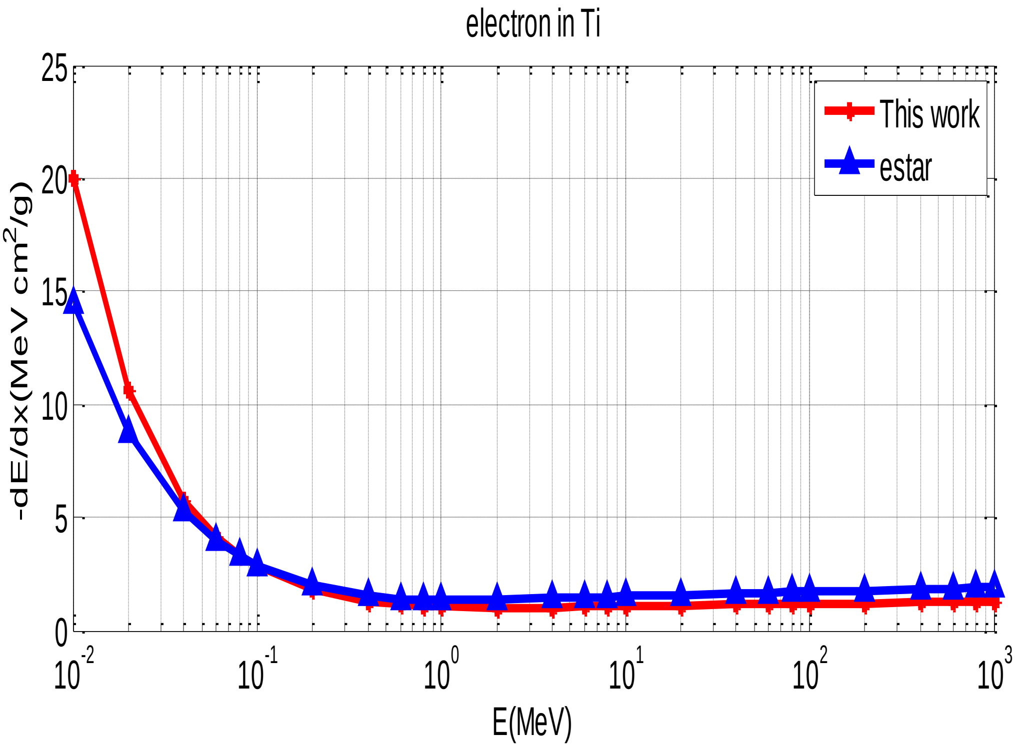

Fig.(b) the collisional stopping power for electron in (Titanium)

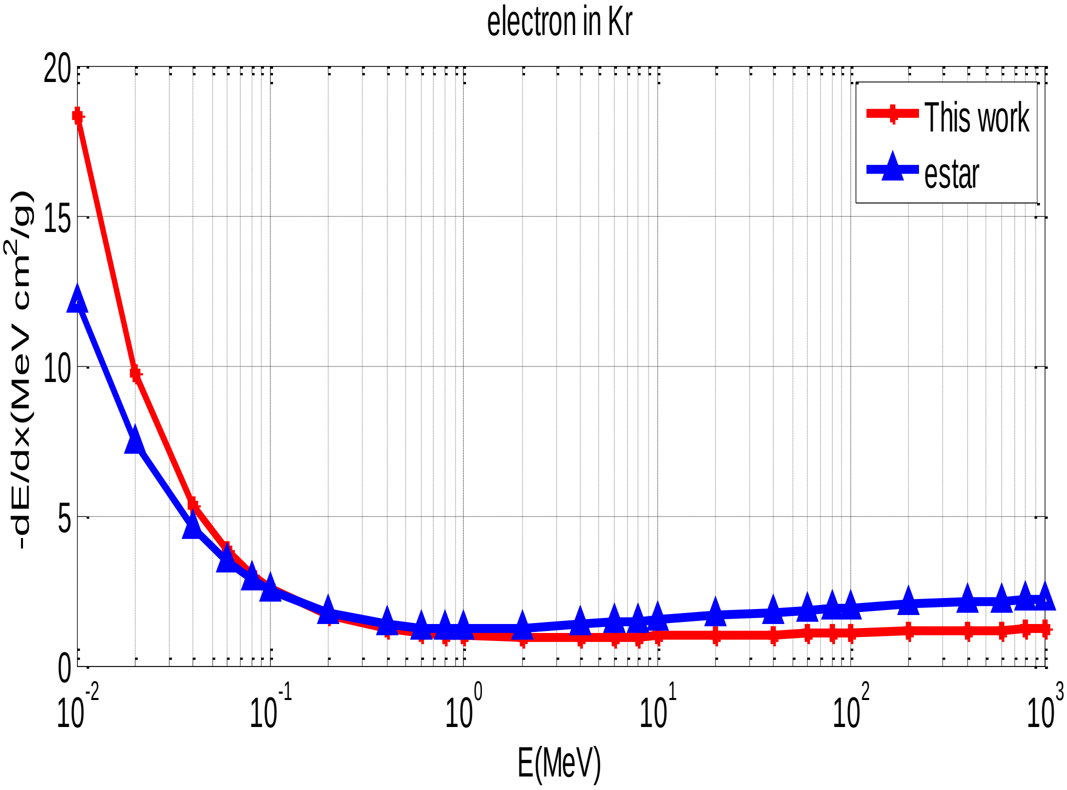

Fig.(c) the collisional stopping power for electron in (Krypton)

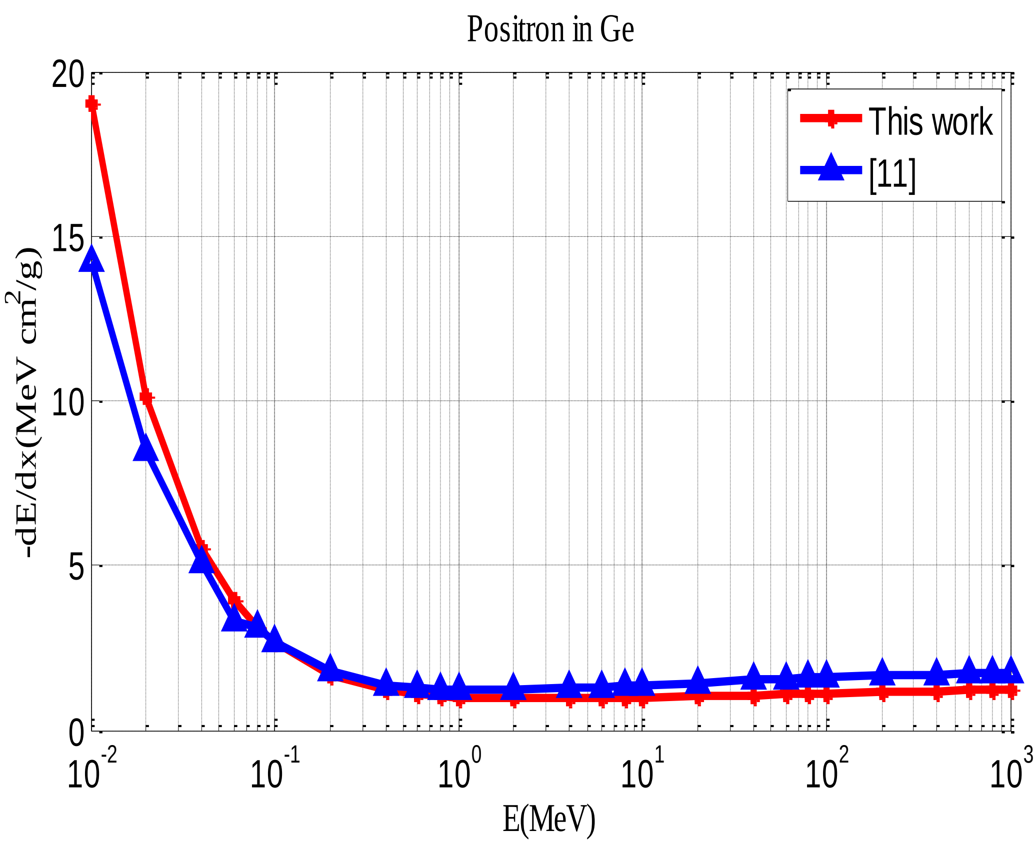

Fig.(d) the collisional stopping power for positron in (Germanium)

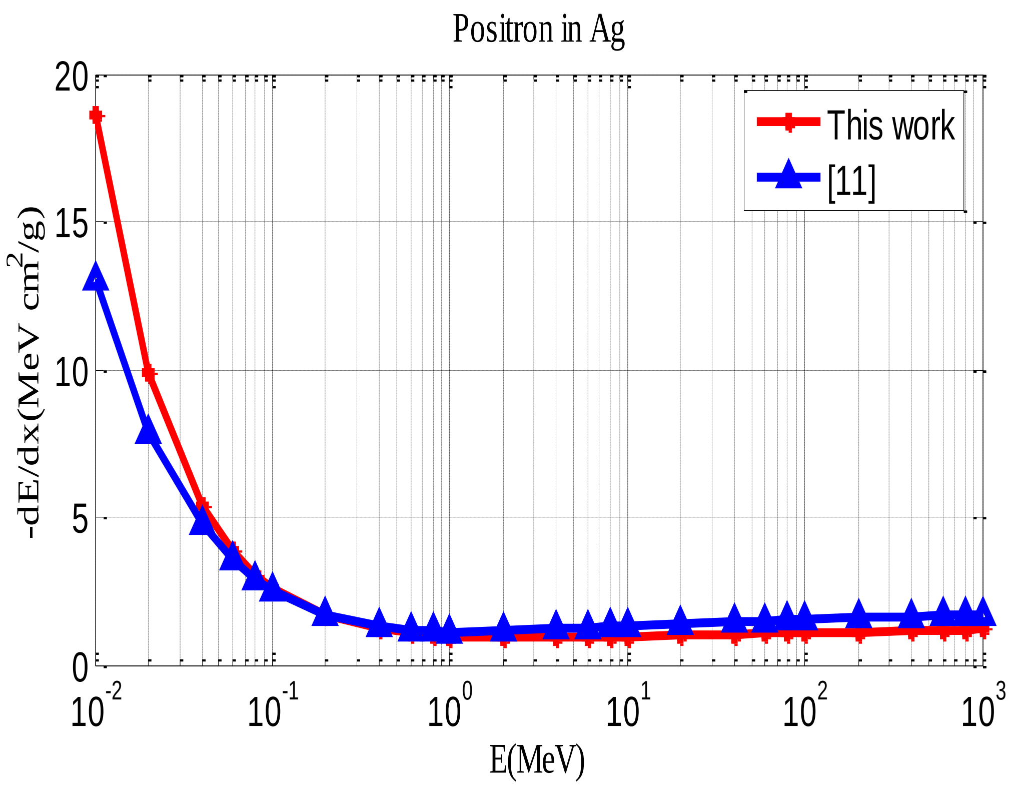

Fig.(e) the collisional stopping power for positron in (Silver)

Table (1) The collisional stopping power and estar results for electron in (B , Ti and Kr)

E(MeV)	$-\frac{dE}{dX}$ (B) (MeV cm^2/g)		$-\frac{dE}{dX}$ (Ti) (MeV cm^2/g)		$-\frac{dE}{dX}$ (Kr) (MeV cm^2/g)	
	This Work	estar	This Work	estar	This Work	estar
0.01	20.6814	18.62	20.0287	14.46	18.3564	12.1
0.02	10.9677	9.113	10.6437	8.737	9.7613	7.437
0.04	6.3665	6.375	5.2015	5.29	5.3237	4.561
0.06	4.5634	4.743	3.9501	3.99	3.6095	3.462
0.08	3.6029	3.887	3.2149	3.298	2.8436	2.874
0.1	3.1836	3.358	2.8106	2.867	2.581	2.506
0.2	2.0431	2.266	1.8995	1.971	1.7534	1.74
0.4	1.5376	1.726	1.4883	1.528	1.3027	1.365
0.6	1.3832	1.566	1.4585	1.402	1.2653	1.263
0.8	1.3143	1.501	1.2518	1.355	1.2042	1.229
1	1.218	1.471	1.2469	1.33	0.9723	1.219
2	1.2294	1.455	1.27111	1.343	1.0307	1.255
4	1.2042	1.499	1.3177	1.405	1.1372	1.352
6	1.348	1.532	1.3323	1.451	1.151	1.422
8	1.4602	1.555	1.345	1.485	1.2629	1.474
10	1.4704	1.572	1.4557	1.51	1.373	1.516
20	1.5048	1.623	1.4914	1.584	1.4063	1.65
40	1.5407	1.672	1.5286	1.648	1.5411	1.782
60	1.662	1.7	1. 597	1.683	1.6617	1.852
80	1.6772	1.72	1.6664	1.707	1.7764	1.901
100	1.6889	1.735	1.6786	1.724	1.8878	1.936
200	1.6956	1.782	1.7065	1.778	1.9233	2.034
400	1.7223	1.83	1.7545	1.828	1.9588	2.117
600	1.7537	1.858	1.7967	1.857	1.9795	2.16
800	1.7989	1.878	1.8025	1.878	1.9943	2.19
1000	1.8008	1.893	1.8147	1.893	2. 057	2.211

Table (2) The collisional stopping power and [12] results for positron in (Ge, Ag)

E(MeV)	$-\frac{dE}{dX}$ (Ge) (MeV cm^2/g)		$-\frac{dE}{dX}$ (Ag) (MeV cm^2/g)	
	This Work	[11]	This Work	[11]
0.01	19.0471	14.24	18.6368	13.03
0.02	10.1163	8.511	9.9027	7.877
0.04	5.5079	5.089	5.3937	4.746
0.06	3.5361	3.304	3.6553	3.56
0.08	3.1411	3.123	3.0771	2.927
0.1	2.6611	2.699	2.6072	2.531
0.2	1.7987	1.819	1.6648	1.706

0.4	1.2312	1.388	1.2071	1.3
0.6	1.1887	1.267	1.0676	1.186
0.8	1.1253	1.221	1.0055	1.143
1	1.0921	1.203	0.9731	1.127
2	1.1486	1.213	0.9307	1.141
4	1.1548	1.273	0.9372	1.207
6	1.2687	1.317	0.9511	1.235
8	1.2808	1.349	0.9631	1.289
10	1.291	1.373	0.9732	1.315
20	1.325	1.448	1.007	1.389
40	1.3606	1.517	1.0422	1.456
60	1.3816	1.553	1.0631	1.491
80	1.4066	1.578	1.078	1.515
100	1.4083	1.596	1.0896	1.533
200	1.4445	1.649	1.1255	1.586
400	1.508	1.7	1.1615	1.636
600	1.5821	1.729	1.1826	1.664
800	1.6172	1.749	1.1975	1.684
1000	1.6289	1.764	1.2091	1.699

Conclusions

1- The stopping capacity of electrons and positrons behaves in a symmetrical manner where they take their greatest value when the particle has a low energy charge and then the energy loss gradually decreases as the velocity of particle increases.
2- It can be concluded that, the employed equation used in the calculation of the collisional stopping power of electrons is valid in the energy range of electrons from 0.04 MeV up to 1000 MeV gives accurate results. positron from 0.06 MeV up to 1000 MeV .

References

[1] R. A. Abbad (2013) "Analytical Study of the Specific energy loss and radiation length X0 of Positron for Chromium Cr ", Journal of Natural Sciences Research Vol.3, No.15.

[2] S.M. Aman Allah (2017)" Study the total Stopping Power of electrons in Beryllium "diyala journal for pure sciences Vol: 13 No:2.

[3] S. R. Babu, N. M. Badiger"(2015) Measurement of Energy Loss of Relativistic Electrons in Aluminum Foil" American Journal of Science and Technology Vol: 2 No:6.

[4] S. K. Rathi , A. S. Verma" (2010)Stopping Power of Electrons and Positrons for C, Al, Cu, Ag, Au, Pb, Fe, U, Ge, Si and Mo" Applied Physics Research Vol. 2, No. 2.

[5] M.Tufan , H. Gumus (2013)" Stopping power and CSDA range calculations for incident electrons and positrons in breast and brain tissues" Radiat Environ Biophys.

[6]B.Yang , S. Fung (2012)"Energy loss of monoenergetic positrons passing through a thin carbon foil"Nuclear Instruments and Methods in Physics Research Section B: Vol.270.

[7] S. S. Kamoon , J. F. Mahdi"34 (2017) Calculation of the total mass stopping power for electrons in some human body tissues in the energy range 0.01-1000 MeV" Iraqi Journal of Physics Vol.15, No..

[8]] N.H.Awan , S.M.Aman (2016)" Stopping Power for Tungsten W " Tikrit Journal of Pure ScienceVol. 21 ,No.1.

[9] S.M.Aman Allah , E. M.Salaman and R. A. Abad (2014)"Estimation Of the Total Energy Loss of Positrons in Copper and Nickel"Pure and Applied Sciences/ Vol. 22 No7.

[10] ESTAR. Stopping power and range tables for electron. Data available. NIST (national institute of standards and technology) http://physics.nist.gov/PhysRefData/Star/Text/ESTAR.html.

[11] M.J. Berger and S.M. Seltzer (1982) Stopping powers and ranges of electrons and positrons. National Bureau of Standards Report NBSIR 82-2550 A .