Simulation of Stopping Power of(0.01-0.1)MeV electron and positron for some Isotones and Isobars Nuclei

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الخلاصة أجريت دراسة نظريه لمحاكاة قدره الإيقاف للإلكترونات والبوزترونات الساقطة على بعض الايزوتونات والايزوبارات الخفيفة والمتوسطة والثقيلة. وقد تم حساب قدرة الإيقاف للايزوتونات ولايزوبارات من خلال تفاعل الالكترونات والبوزترونات مع المادة باستخدام برنامج حاسوبي بلغة الماتلاب اعتمادا على طرق رياضية نظرية استقرائية وكذلك تصميم كود لحساب قدرة الايقاف الالكترونية بمدى طاقة تتراوح بين (0.1-0.01)MeV وكان التوافق الجيد بين النتائج التي حسبت باستخدام البرنامج مع النتائج العملية.

Abstract

A theoretical studying was made to calculate the stopping power for (electron and positron) particles falling on some heavy, middle and light (isobars, isotones) nuclei. Calculated of the stopping power was made for (isobars, isotones) depending on the interaction (electron and positron) with a material by using Matlab language program depending on inductive mathematical theoretical methods, computational and design code to calculate the stopping power from (0.01- 0.1) MeV. A good agreement between experimental results and calculated stopping power computed by the program(work).

Key words: (stopping power, electrons, positrons, Isobars, Isotones, Matlab language).

Introduction

Penetration charge heavy and light particles such as (Positron, electron, Proton, Neutron and alpha particles) is important subject in the atomic physics have been studied by several investigator and calculated by using different formulas, the first investigator studied stopping power was the Niles Boher (1913),who improved its theoretical structure by using classic mechanic, He consider the energy loss from charge particles due to collision with atomic electron and the atom of electron can consider a static freedom approximately before collision with incident particles [1]

Stopping Power

The energy loss per units of length or thickness when the heavy or light particles moving through its path in medium with kinetic energy (T) is called stopping power .The energy losses can be express as S(E)=($-\frac{dE}{dx}$) expressed with unite

of (MeV/m) or some time express by unit ($MeVcm^2/g$) because of the energy loss per area density:

$dx = \rho ds$

Where ρ: is the density in $\left(\frac{g}{cm^3}\right)$

and ds : is the length in cm

Stopping power is depending on charge of projectile(particle)and nature of target (material) [2]. The subject of stopping power is very important in our life for example there are more application for many parts of basic science, industry, nuclear physics and medical treatment [3].

Stopping Power and its Formulas for Light Particles

The loss energy process by particles in matter should be measurement theoretically or experimentally by high accuracy and studying the target material and how it interacts with charge particles, so the charge particles passing through medium its interaction with the atoms target, this will be product from electromagnetic force

between the charge particles. This interaction can be divided into two parts, elastic collision with all nuclear atoms and inelastic collision with atom electrons depending on the nature of interaction [3,4]. When particle moving through matter with energy (T), Its well ionized and loss its energy gradually then become zero, because of coulomb force has infinite range. The distance in which particle travelling in matter is called the range [5].

The total stopping power can be expressed as follows:

$$\left(-\frac{dE}{dx}\right)_{total} = (S)_{electronic} + (S)_{nuclear} \quad (1)$$

Where (S) is the stopping power [6].

In such a way as to calculate the energy deposed in matter is being (negative sign) because the loss energy of the particles [7].

To treatment the maximum energy transfer ,has already shown that the incident electrons in compare to the heavy particles such us (alpha particles ,proton) , ($m_\circ \gg m_e$) this is played special roles .in order to give the energy loss for heavy particles we can use the Bethe and Bloch formula for the energy loss (dE) per (dx) is given as [8] :

$$-\frac{dE}{dX} = 4\pi N_A r_e^2 m_e C^2 z^2 \frac{Z}{A} \frac{1}{\beta^2}\left(\mathrm{Ln}\left(\frac{2m_e \beta^2\gamma^2 C^2}{I}\right) - \beta^2 - \frac{\delta}{2}\right) \quad (2)$$

for energetic particles, δ can be approximated by:

$$\delta = 2\ln\gamma + \xi \qquad (3)$$

We can write the formula (2) which called (Beth-Bloch) formula as:

$$-\frac{dE}{dX} = 2\mathrm{k}\left(\mathrm{Ln}\left(\frac{E_{kin}^{max}}{I}\right) - \beta^2 - \frac{\delta}{2}\right) \qquad (4)$$

The equation (2) we can not be used its at slow energies for energy losses of charge particles by ionization and excitation in matter which are compare to the those of atomic electrons for these velocity ($\alpha z \gg \beta \geq 10^{-3}$) where $\alpha = \frac{e^2}{4\pi\varepsilon_\circ C\hbar}$

Therefor the energy lose is proportional with (β) [9].

The equation (2) is can be used at($\beta \gg \alpha z$) [10].For condition of energy lose in the low energy its decrease with some parameter like ($\frac{1}{\beta^2}$) , and energy lose increased when ($\gamma > 4$) because of logarithms in the equation (2), but the

increase does not depend on some parameter for example ($2ln\gamma$)[11] .

The energy losses at the ionization minimum with increasing of atomic number from the part (Z/A) of equation (2), that mean the large logarithmic of the energy transfer to few electrons in the matter [11].

For heavy particles projectile. Equation (1) described the energy losses due to ionization and excitation at high energy [12]. we can write The general formula. for the most probable energy loss is [11]:

$$dE^W = \xi\left[ln\left(\frac{2m_e\ C^2\gamma^2\beta^2}{I}\right) + Ln\frac{\xi}{I} + 0\cdot 2 - \beta^2 - \delta(\beta\gamma\right] \qquad (5)$$

Where :

$$\xi = 2\pi N_A\, r_e{}^2 m_e\, C^2\, z^2\, \frac{Z}{A}\, \frac{1}{\beta^2}\rho x = k\rho x$$

The full expression for the Bethe-Bloch formula of electron can be written as in (MeV/m) [13]:

$$-\frac{dE}{dX} = 4\pi\, r_\circ{}^2 m_e\, C^2\, N\, Z\, \frac{1}{\beta^2}\left\{\left(\mathrm{Ln}\left(\frac{\gamma\beta\, m_e\ C^2\sqrt{\gamma-1}}{I\sqrt{2}}\right)\right.\right. \frac{1}{2\gamma^2}\left[\frac{(\gamma-1)^2}{8} + 1 - (2\gamma^2 + 2\gamma - 1)\right]\ln 2\left.\left.\right)\right\} \qquad (6)$$

for completeness, we also give the ionization loss of positrons as [14]:

$$\frac{dE}{dX} = 4\pi N_A\, r_e{}^2 m_e\, C^2\, \frac{Z}{A}\, \frac{1}{\beta^2}\left\{\left(\mathrm{Ln}\left(\frac{\gamma\beta\, m_e\ C^2\sqrt{\gamma-1}}{I\sqrt{2}}\right)\left[23 + \frac{14}{(\gamma+1)} + \frac{10}{(\gamma+1)^2} + \frac{4}{(\gamma+1)^3}\right]\right)\right\} \qquad (7)$$

or we can write the energy loss formula for positron in(MeV/m) [13] as below:

$$-\frac{dE}{dX} = 4\pi\, r_\circ{}^2 m_e\, C^2\, \mathrm{ZN}\, \frac{1}{\beta^2}\left\{\left(\mathrm{Ln}\left(\frac{\gamma\beta\, m_e\ C^2\sqrt{\gamma-1}}{I\sqrt{2}}\right) - \frac{\beta^2}{24}\left[23 + \frac{14}{(\gamma+1)} + \frac{10}{(\gamma+1)^2} + \frac{4}{(\gamma+1)^3}\right] + \ln 2\right)\right\} \qquad (8)$$

Where: $\rho = \frac{N_A}{A}$

equation (6) represent collisional stopping power for relativistic electrons and equation (8) represent collision stopping power for relativistic positrons [13]. At low energies the stopping power is usually describe as electronic stopping power [14].

Results and Discussion

The stopping power have been calculated for some (isobars and isotones) by using (electron and positron) projectiles with energy ranging between(0.01-0.1)MeV,fig (1,2,3,4,5,6,7,8,9,10) and by using equations(6and8)then programned this equations with matlab language program, results showed that identification and a good agreement between experimental results and calculated stopping power computed by the program(work), Fig. (3and4) by using program with Matlab language ,This leads the imporant of this program to calculate the stopping power between (0.01-0.1) MeV.in fig. (6and9)The stopping power have been calculated for ($^{110}_{48}Cd$ ‚ $^{110}_{46}Pd$) isobars and($^{176}_{72}Hf$ ‚ $^{176}_{70}Yb$) isobars result showed that the stopping power different from isobars to other at low atomic number and the collision Stopping power decreased when the energy of projectile increased at low energy , fig. (2,5,6and9) , because of the factor ($\frac{1}{\beta^2}$) in equations (6and8) ,which used calculation the stopping power .The stopping power is increasing in isobars when the atomic number(Z) is increasing fig. (2,6),where the stopping power of ($^{110}_{48}Cd$) larger than ($^{110}_{46}Pd$) in fig (6)and stopping power of ($^{14}_{7}N$)larger than ($^{14}_{6}C$) fig.(2) because of decreasing neutron number in ($^{110}_{48}Cd$) and ($^{14}_{7}N$) .In fig. (1,7,8and10) the stopping power have been calculated for isotones by using formulas (6and8), result showed that the stopping power different from isotone to other at low atomic number, where the stopping power of ($^{19}_{9}F$) larger than ($^{18}_{8}O$) isotone because of increase in atomic number (Z)

and the effect of the part ($\frac{Z}{A}$) in equations (2,7)

Conclusion

There are some results we have been found in this research for example below:

1-The stopping power is different from isobars to other as well as its different from isotone to other and the important of equations (6and 8) for calculate stopping power at low energy.

2-Product identification and a good agreement between experimental results and calculated stopping power computed by the program at range (0.01-01) MeV electron and positron. 3-The stopping power proportional with atomic number (Z)of target (Isobars and Isotones).

4-The important parameters that of stopping power for electrons and positrons depend on it are (atomic number(Z), atomic mass (A), excitation energy (I), logarithm part and ratio ($\frac{Z}{A}$) in equations (6 and 8).

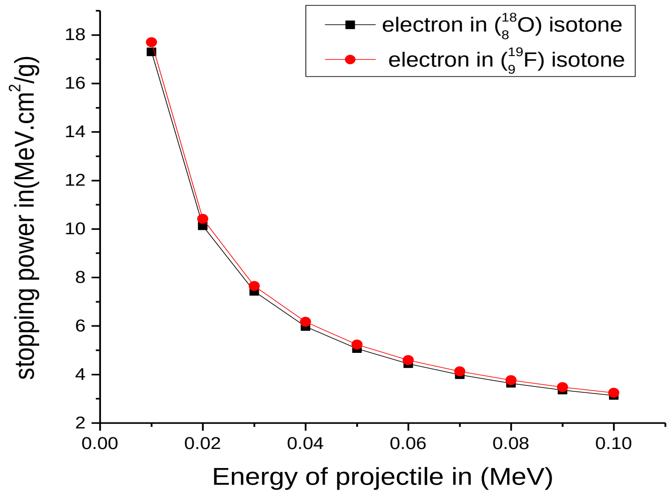

Fig.(1) The relation between stopping power and energy of (0.01-0.1) MeV electron particle incident in ($^{18}_{8}O$, $^{19}_{9}F$) isotones.

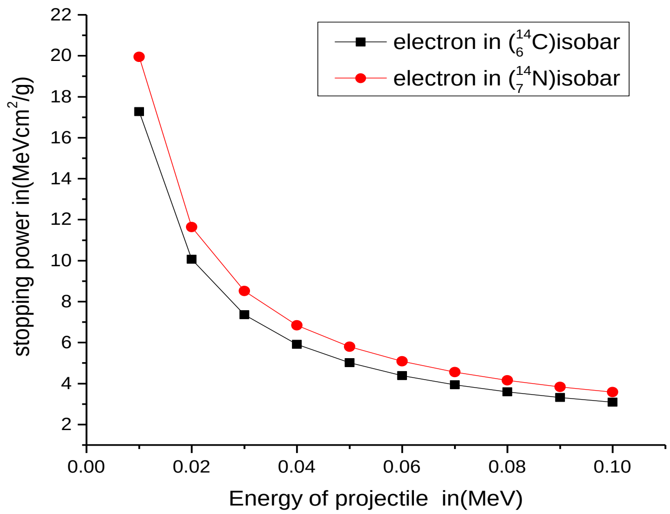

Fig. (2) The relation between stopping power and energy of (0.01-0.1) MeV electron incident in ($^{14}_{6}C$ ¸ $^{14}_{7}N$)isobars .

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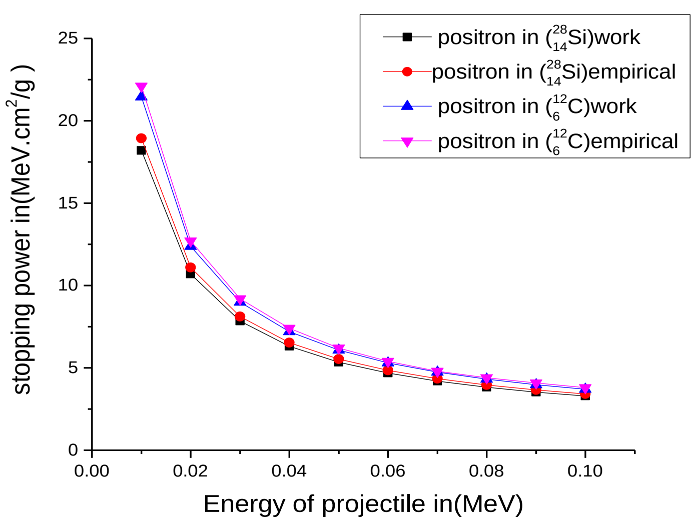

Fig .(3) Comparison between the working value and empirical value of stopping power for (0.01-0.1)MeV positron incident in ($^{28}_{14}Si$¸ $^{12}_{6}C$) .

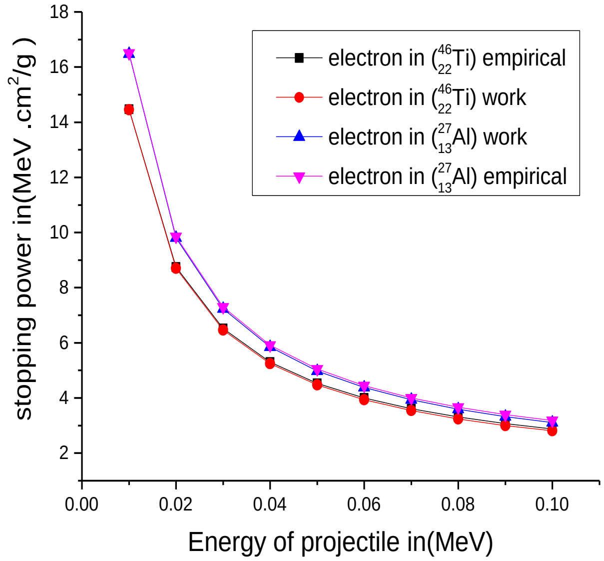

Fig .(4) Comparison between the working value and empirical value of stopping power for(0.01-0.1)MeV electron incident in ($^{27}_{13}Al$,$^{46}_{22}Ti$).

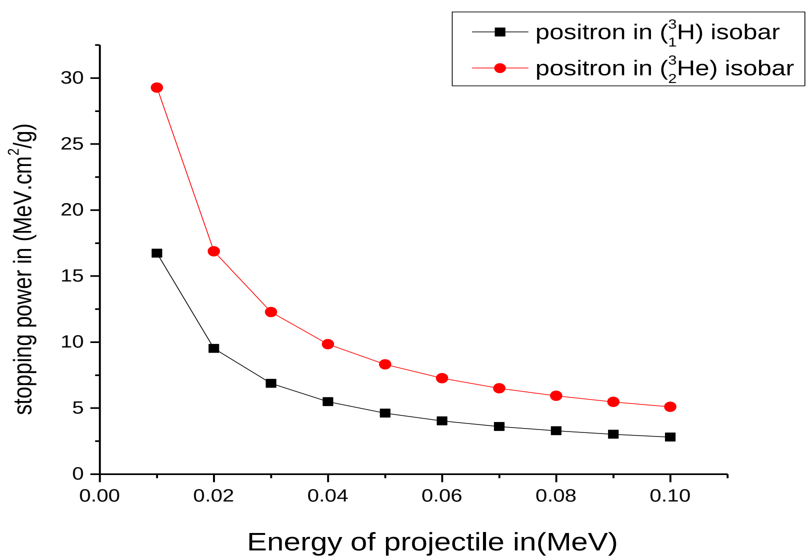

Fig.(5)The relation between stopping power and energy of(0.01-0.1) MeV Positron incident in (^3_1H,^3_2He) isobars.

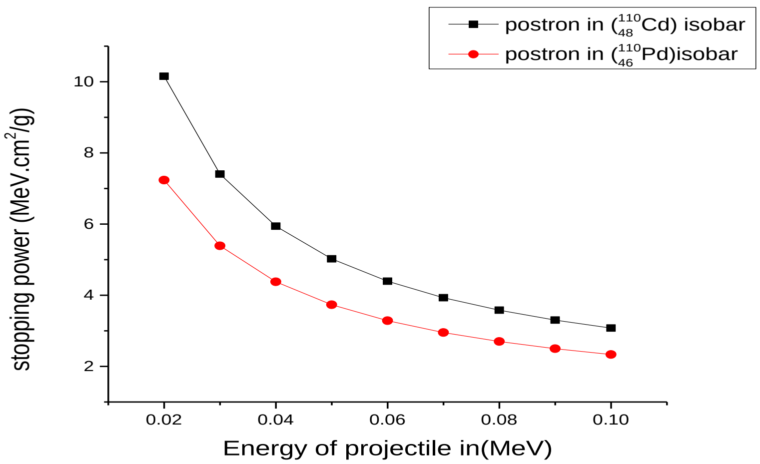

Fig.(6)The relation between stopping power and energy of(0.01-0.1) MeV Positron incident in ($^{110}_{48}Cd$, $^{110}_{46}Pd$) isobars.

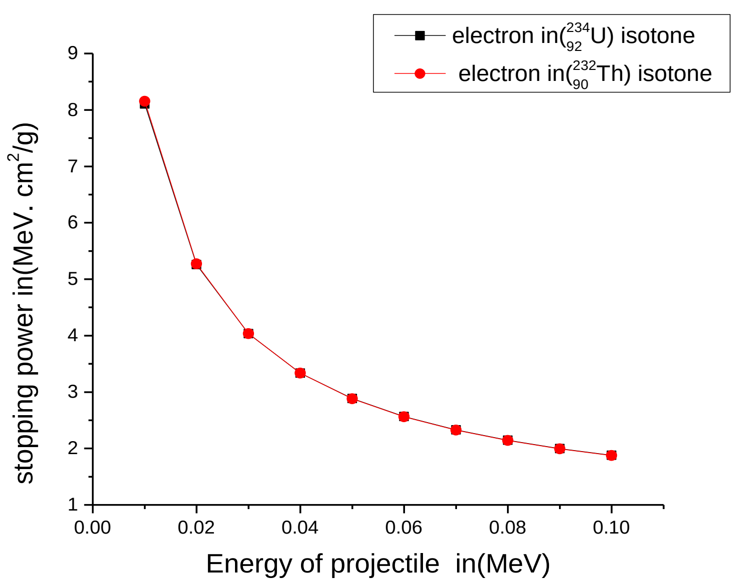

Fig. (7) The relation between stopping power and energy of(0.01-0.1)MeV electron incident in ($^{232}_{90}Th$, $^{234}_{92}U$) isotones.

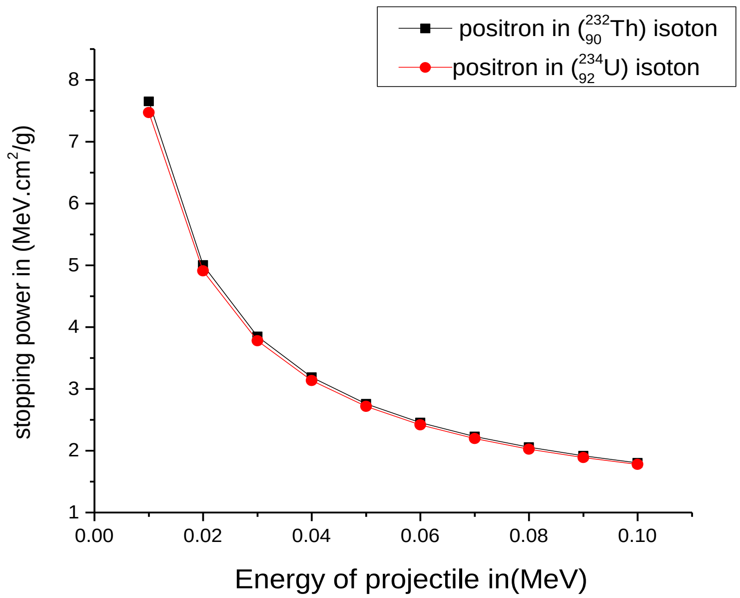

Fig. (8) The relation between stopping power and energy of positron incident in ($^{232}_{90}Th$, $^{234}_{92}U$) isotones.

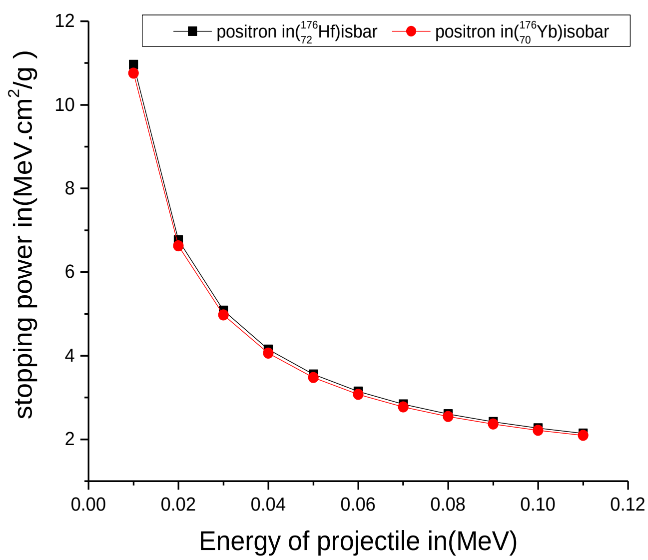

Fig. (9) The relation between stopping power and energy of (0.01-0.1)MeV positron incident in ($^{176}_{72}Hf$, $^{176}_{70}Yb$) isobars.

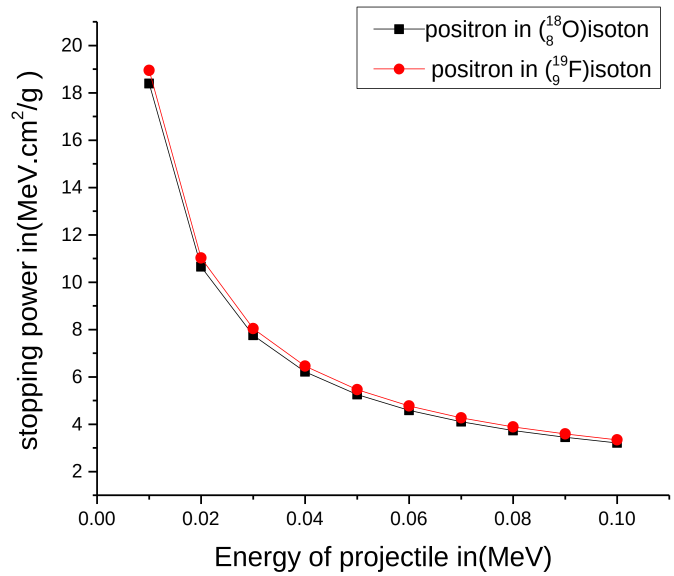

Fig .(10) The relation between stopping power and energy of (0.01-0.1)MeV positron incident in ($^{18}_{8}O$, $^{19}_{9}F$) isotones.

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