Calculation of Electronic Stopping Power for Protons in Atomic Targets

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Abstract: ***Was calculated and the study of the electronic stopping power of heavy charged particles (protons) interacting with atomic goals(Sm,Er,w,Pb,H^{+1},H^{+2}) We used the program SRIM 2013 who wrote by MATLAB languageCalculated Stopping power The extent of energy protons (0.5-1000)MeVUsing the equations fitting We reached three semi-empirical relationships and we calculated the error rate and the correlation coefficient and the relationship between (SRIM) the experimental similarities by program Curve Expret The result was a match program SRIM .***

Keyword: proton stopping power, atomic targets.

1. Introduction

Fast charged particles when they enter the center of a material, the electrons and nuclei interact in the middle and can explain this interaction between charged particles and Ktsadmat Tbdibvkdan energy whenever pierced center[1].Stopping power Is the energy lost to the grave charged rate per unit length of the track and written form($-dE/dX$) Divided Stopping power to stopping power the electronic and nuclear[2]. The particles of light and heavy stopping power It depend mainly and directly on the charge projectile and shipment mass and speed, and increase the gross energy lead to decrease stopping power linear This means it is written inversely proportional to the energy projectile. The first theory to model the energy of heavy charged in material loss is the classical theory in year 1913 Formula and the stopping of this model by using the classical dispersion theory Amid stopping Described by oscillating harmonic [3]. Then the world was able to find a relative of Beth equation through which calculate the electronic suspension based on the ability of quantum mechanics He explained the process of collision between the charged particle and the electrons in the atom high energies [2]. World and Bloch was able to derive a number of suspensions mail to Bohr model velocities in low-lying and model Beth at high velocities and explained the corrections to the number of suspensions for Beth fail properly fitting boron near collisions[4]. When a material is irradiated with charged particles of a certainenergy, such as protons, alpha particles or heavy ions, the incident particle progressively loses its energy in large part due to inelasticcollisions with atomic electrons. Theoretically, the energy lossdE due to these interactions is commonly described by the well known Bethe–Bloch formula of the stopping power S (E). Additionally, a higher-order correction proportional to $Z_1^4 L_2(\beta)$to the stopping power formula has also been predicted, which connects the classical stopping power theory with the quantum–mechanical approach. This correction, known as the Bloch term can be calculated using the next equation [5] :

$$L_2 = \Psi(1) - Re[\Psi(1+iy)] = -\left(\frac{1}{y^2}\right)\sum_{i=1}^{\infty}\frac{1}{i(i^2+y^2)} \quad \ldots\ldots(1)$$

$y=\frac{Z_1}{\beta}\alpha$

There is some empirical relations stopping power proton Including [6].
$-\frac{dE}{dX} = \frac{a}{A_2}E^{-b}Z_2^{c\ LogE+d}$ ...(2).of the constants are a=915 ,b=0.85 ,c=0.145 and d= 0.635 ,ρ they density, A_2 Atomic weight,Z_2 Atomic number of the material Discontinued,E Kinetic energy of the projectile units MeV/amu Above is correct and that the relationship within the range of energy (0.7-12)MeV and stopping power units MeVcm^2/gm .constant(c,d) Was found to be independent of the type of particle has been obtained from matching(fitting). While stopping power semi -empirica heavier than protons can be found by the equation[6].

$$\left(-\frac{dE}{\rho dX}\right)_H = \frac{Z_{eff}^2}{\gamma_p^2}\left(-\frac{dE}{\rho dX}\right)_P \quad \ldots..(3)$$

$Z_{eff}^2 = \gamma^2 Z^2$, Here power over 0.7MeV So protons $\gamma_{P=1}$ Compensation equation(1) in(2)

$$\left(-\frac{dE}{\rho dX}\right)_H = \gamma^2 Z^2 a E^{-b} Z_2^{cLogE+d} \quad \ldots\ldots(4)$$

γ, Break the effective charge of the ion energy E(MeV/amu) And can be guessed from the empirical formula for Both andGrant [6],$\gamma^2 = f(E_z^{-4/3})$.wheref(x)=1-exp(-24.73x+247.6x^2-1131x^3).

2. Results and Discussion

Was calculated stopping power proton In six different elements of the energy (0.5-1000)MeV The program has been implemented in a language MATLAB 2009 .

a)fitting equation

By program SRIM 2013 Which was implemented in MATLAB program We have used a curved fitting We reached the equation constants a,b,c As in Table(1) In the six elements .

$$-\frac{dE}{dX} = aE^b + c \quad \ldots\ldots(5)$$

E Kinetic energy of the proton,$\frac{dE}{dX}$ Eelctronic Stopping Power.

b) Empirical formula similarities to the stopping power the proton We have reached a formula quasi-experimental six different elements of the same extent mentioned energy Bloatmad the atomic number and mass of the central and ionization potential.

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$$-\frac{dE}{dX} = abE^{-1} \qquad \dots\dots(6)$$

a=$x_1({}^{Z_2}/_{A_2})$, b=Log$(x_2 + 2.7 \times 10^3(\frac{E^{1.5}}{I}))$

$-\frac{dE}{dX}$ Eelctronic Stopping Power units (MeV.cm^2/mg) ,(E) Energy proton ,(Z) Atomic number of the target ,(A) The mass number of the target ,(I) ionization potential of the target ,(x_1,x_2)variables

$x_1 = 0.132$, $x_2 = 2.8$ $when\ A_2 = 1$

$x_1 = 0.260$, $x_2 = 2.8$ $when\ A_2 = 2$

$x_1 = 0.100$, $x_2 = 1.8$ $when\ A_2 > 2$

Through the semi empirical formula we got results agreement with the program SRIM 2013 .From these figures (1),(2),(3),(4),(5), and(6)we concluded that results are very good .

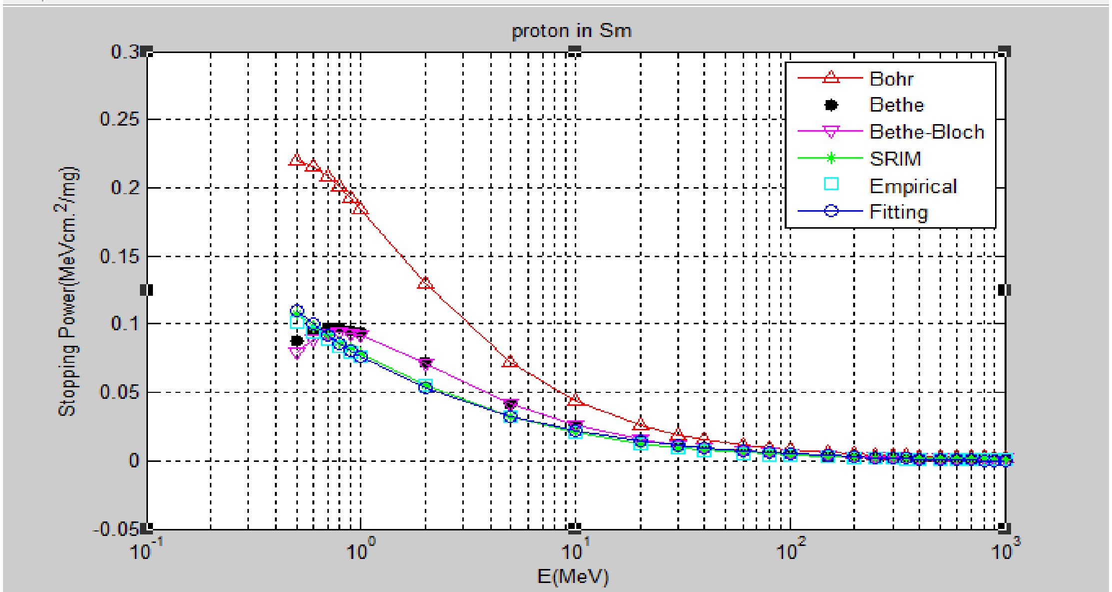

Figure 1: Shows the relationship between the stopping power and energyof element sm was the correlation coefficient(0.999961)and the error ratio (0.000256) .

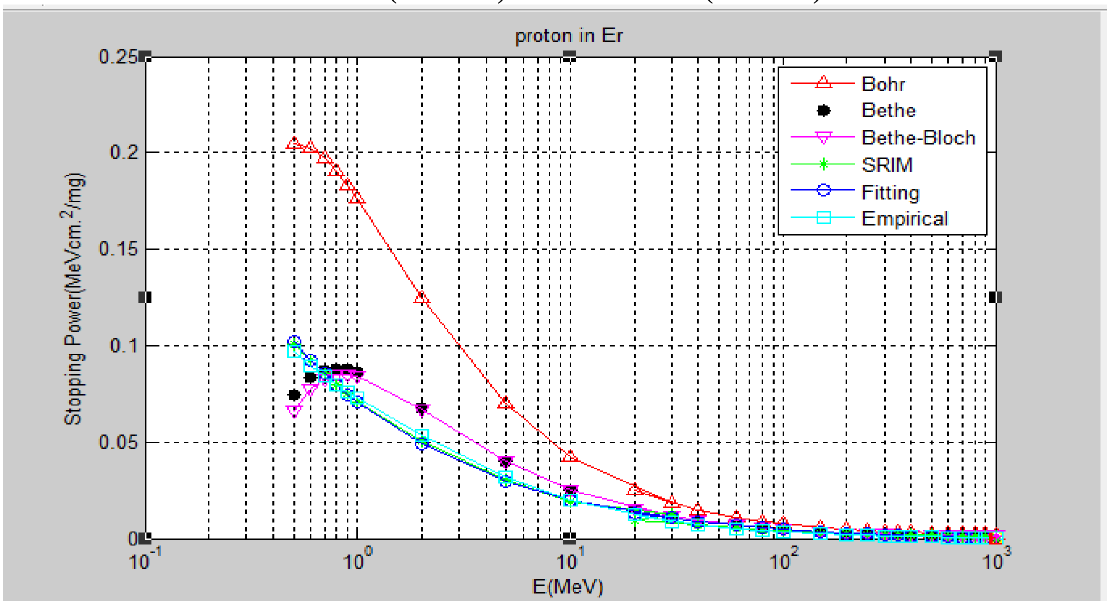

Figure 2: Shows the relationship between the stopping power and energyof element Er was the correlation coefficient (0.999969)and the error ratio (0.000688)

Table 1: shows the constants of the six circles in the equation (5).

element	a	b	c
H^{+1}	0.6404	-0.7435	0.003188
H^{+2}	0.6402	-0.7436	-0.003061
W	0.06631	0.4777	-0.002452
sm	0.0789	-0.5087	0.02444
Er	0.07242	-0.521	0.00181
Pb	0.06432	-0.5143	-0.01562

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