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density correction dependent to electronic energy loss calculation of protons in thorium, lithium, and lithium carbonate

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Abstract . In this research, electronic energy loss of protons in targets (thorium, lithium, and lithium carbonate) was calculated using Bloch equation with density correction at energy range (5-1000) MeV and the results were compared with the practical program SRIM for the quantitative Bloch equation, so its results with density correction are closer to the practical program used To compare for the items used in the search, but it records a small difference for the vehicles at the beginning of the range
Key words: density Correction, Bloch equation, SRIM ,Stopping power

1. Introduction:

The energy loss of a particle per unit length of its journey in a given medium is known as stopping power, and it is calculated using the formula "–dE / dx," where "–dE" stands for stopping power and "dx" for path length increase[1]. Because of their physical characteristics, heavy charged particles play a crucial role in radiotherapy. When these charged particles travel through a medium, their ionization rate, or stopping power, rises as their speed decreases. Electron and proton are used in medical diagnostic and therapeutic procedures. [2]. Since a proton is regarded as a heavy charged particle, an electron is a light charged particle with a mass substantially less than that of a proton[3]. After summing the energy lost from the impact and radiation, the total energy lost was determined, allowing for the calculation of stopping power. [4] F. Maas worked on the interaction of particles with matter and the importance of computing the density correction in the Bethe-Bloch formula with particle energy above 1GeV [5] S. Ramesh Babu, N. M. Badiger ,The stopping power of relativistic electrons in thin (Al) foil has been measured to understand the mechanism of interaction of electrons with matter. The 948 keV and 1022keV[6] Z.H.muter ,R.O.Kadhim studied the values of loss energy using density correction for electron in C_2H_4O ,C_3H_6, C_3H_9N in the energy range of 0.01-1000MeV[7] The aim of the present work is to calculate the loss energy using the Bloch formula and density correction for protons passing through thorium, lithium, and lithium carbonate with different energies and studying different parameters affecting the stopping power.

2. Stopping power:-

In a relativistic treatment the stopping power for fully stripped ions reads[8]

$$-\frac{dE}{dx}=\frac{4\pi z_1^2 e^4}{m_e v^2} NL_{Bethe} \qquad (1)$$

N: target density.

z_1:atomic number of projectile.

v: projectile velocity

L:stopping number.

m_e :electron mass.

e : electron charge

Relativistic adjustments to the Bloch formula are required at very high projectile velocity; the relativistic Bloch formula can be expressed as [9]

$$-\frac{dE}{dx}=\frac{4\pi z_1^2 e^4}{m_e v^2} N\ln(\frac{2m_e v^2}{I}-\frac{C}{Z_2}-\beta^2-\frac{\delta}{2}) \qquad (2)$$

where $\frac{C}{Z_2}$, the target shell corrections $\frac{\delta}{2}$ and the density effect correction , β Relative particle velocity , I mean ionization energy correction

$$\beta=\frac{v}{c}$$

where density effect correction plays a crucial role in the relativistic rise energy loss phenomenon and reduces collision energy loss due to the incident charged particle's passage through the middle's polarization. Density effect correction takes the following form:[10, 11]

$$\frac{\delta}{2}\to\ln\left(\frac{\hbar w_0}{I}\right)+\ln\beta\gamma-\frac{1}{2} \qquad (3)$$

where $\hbar w_0$ is the plasma energy $=\sqrt{4\pi N_E r_e^3}\ \ m_e c^2/\alpha = 28.816\sqrt{\rho(\frac{Z}{A})}\ eV\ for\ \rho\ in\ g\ cm^3$ γ Lorentz factor . The effect of density is negligible at some low as well as some high energies as it is well described using Equation. (3),proposed the parameterization [12]

$$\delta=\begin{cases} 2(\ln 10)r-C^- & \text{if } r\geq r_1 \\ 2(\ln 10)r-C^-+a(r_1-r)^k & \text{if } r_0\leq r<r_1 \\ 0 & \text{if} r<r_0(\text{noncondution}) \\ \delta_0 10^{2(r-r_0)} & \text{if } r<r_0(\text{condution}) \end{cases} \qquad (4)$$

Where $r=\log_{10}\beta\gamma$

$$C^- = -2\ln\left(\frac{I}{\hbar w_0}\right)-1\ [9]$$

And k 3.00 , $a=\frac{C^- -2(\ln 10)r_0}{(r_1-r_0)^3}$

For solids and liquids

$$r_1 = \begin{cases} 2.0 \text{ if } I < 100\text{eV and } r_0 = \begin{cases} 0.2 & \text{if } C^- < 3.681 \\ 0.326C^- - 10 & \text{otherwise} \end{cases} \\ 3.0 \text{ if } I \geq 100 \text{ eV and } r_0 = \begin{cases} 0.2 & \text{if } C^- < 5.215 \\ 0.326C^- - 1.5 & \text{otherwise} \end{cases} \end{cases}$$

3. Results and discussion :-

The figures shows the relationship between the studied loss through density correction as a function of energy, as the calculations were compared with the practical values of SRIM 2013 [13].

Figure (1,2) When the target was thorium, we notice that Bloch equation with density correction gives results that are close to the practical program, especially at energies higher than 15 MeV, meaning high energies, as the effect of density increases with the increase in the energy of electrons falling on the absorbing media, but when the medium was lithium It records a good agreement with the practical program for calculating energy loss from the beginning to the end of the run.

Figure (3) When the target was the lithium carbonate compound, we notice that it behaves the same with a difference in the values of the stopping power in addition to the difference between the two curves at the beginning of the range and up to the range 60MeV, meaning that the effect of density correction is at high energies only.

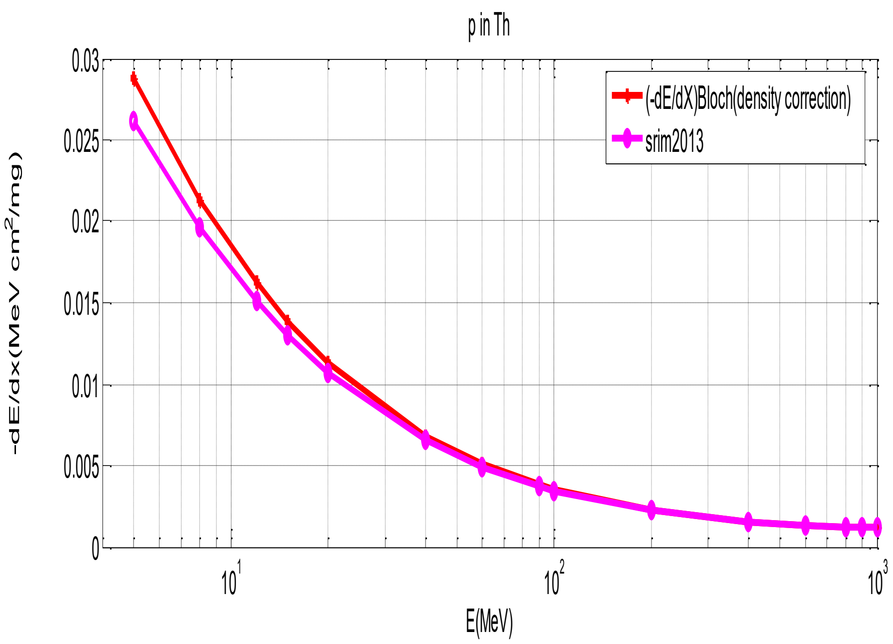

Fig.(1) stopping power for proton in (Th)

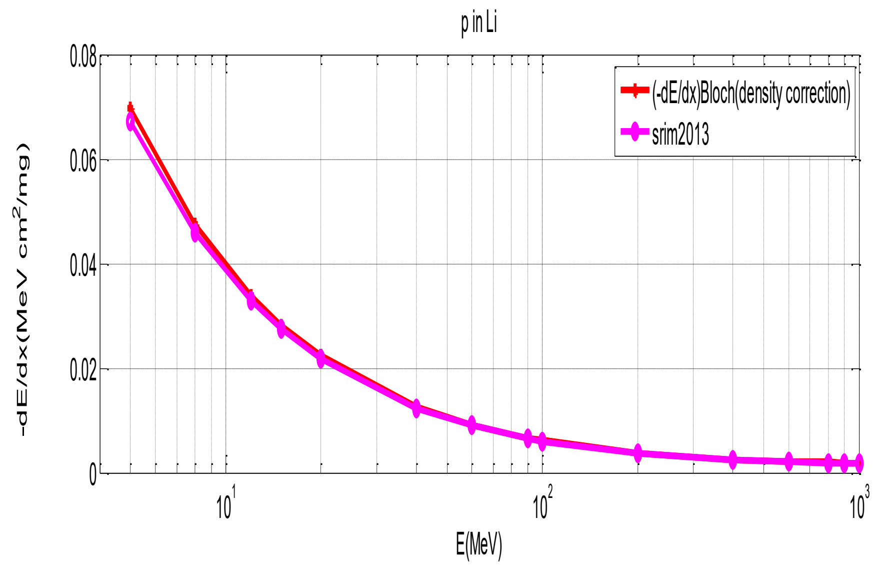

Fig.(2) stopping power for proton in (Li).

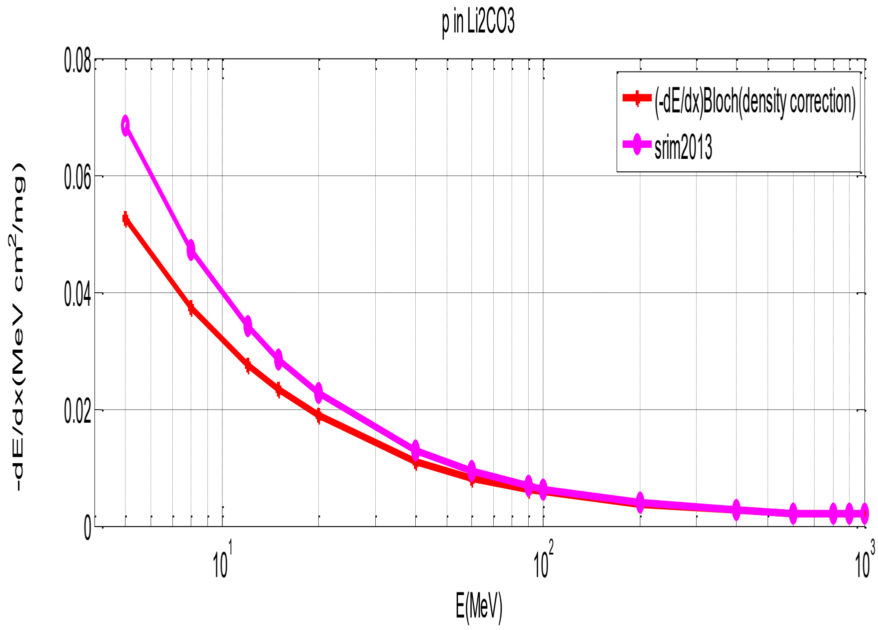

Fig.(3) stopping power for" proton "in (Li_2Co_3).

E(MeV)	DENSITY(Th)	SRIM	DENSITY(Li)	SRIM	DENSITY(Li2CO3)	SRIM
5	0.0287	0.0262	0.0698	0.0672	0.0526	0.0684
8	0.0214	0.0196	0.0475	0.046	0.0372	0.0472
12	0.0162	0.0151	0.034	0.033	0.0275	0.0342
15	0.0139	0.013	0.0282	0.0275	0.0233	0.0285
20	0.0113	0.0107	0.0222	0.0217	0.0187	0.0226
40	0.0068	0.0066	0.0126	0.0123	0.0111	0.0129
60	0.0051	0.0049	0.0091	0.009	0.0082	0.0094
90	0.0038	0.0037	0.0066	0.0065	0.0062	0.0068
100	0.0035	0.0035	0.0061	0.006	0.0057	0.0063
200	0.0023	0.0022	0.0037	0.0037	0.0037	0.0039
400	0.0016	0.0015	0.0025	0.0025	0.0026	0.0026
600	0.0013	0.0013	0.0021	0.0021	0.0022	0.0022
800	0.0012	0.0012	0.002	0.0019	0.0021	0.0021

900	0.0012	0.0012	0.0019	0.0018	0.002	0.002
1000	0.0012	0.0012	0.0019	0.0018	0.002	0.002

4. Conclusion

From this study, Bloch density correction equation is valid for this type of calculation, , it is suitable for calculating the energy loss of the elements studied in the research. The equation gives good results for lithium sulfate compound at energies higher than 60 MeV.

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