Study of Nuclear Transparency in Proton- Nucleus Collisions For 20 GeV/c ≤ p_{mom}≤ 60 GeV/c

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Introduction

The absorption cross-sections of hadrons (i.e. p, p^{-}, $\pi^{\pm}$, $K^{\pm}$, etc.) interacting with target nuclei have been measured by different groups of scientists over widely different energy ranges [1-5] on a large number of nuclei from 'He' to 'U'. Theoretically, these absorption cross- sections have been parameterized by considering de-Broglie's wave length of the incident hadrons [6, 7]. Mehta and Kailas [8] modified this parameterization by introducing a new parameter, called transmission coefficient (T). Latter, Agrawal and Gupta *et al.,* [11] also adopted this modified formula. Some other physicists [3, 9 and 10] gave the expression of absorption cross-section depending upon atomic mass number of target nuclei at a single energy. Several studies [12-14] have now been done in which atomic mass dependence of σ_{abs} has been investigated.

In the present paper we study the nuclear transparency in proton-nucleus interactions for 20 GeV/c ≤ p_{mom} ≤ 60 GeV/c momentum range. In our study we include different target nuclei (i.e. Li, Be, C, Al, Cu, Sn, Pb & U) with light, medium and heavy mass.

Procedure of Present Calculation and Analysis

The values of proton (p) absorption cross-section are calculated using the energy dependent black disc formula

$$\sigma_{abs} = \pi(R + \bar{\lambda})^2 \quad \textbf{(1)}$$

with $\bar{\lambda} = \lambda/2\pi$, where λ is the wavelength of the proton and R is the radius of the target nucleus and given by $R = r_0 A^{1/3}$

The parameter r_0 is taken 1.5 fermi as earlier physicist used [7, 8]. The σ_{abs} is calculated for 20 GeV/c ≤ p_{mom}≤ 60 GeV/c of eight nuclei, i.e. Li, Be, C, Al, Cu, Sn, Pb and U.

Comparison of calculated values of σ_{abs} with the corresponding available experimental values shows that the calculated values of σ_{abs} are consistently higher than the latter.

Thus, the expression (1) requires some modification if agreement between the experimental and calculated values of σ_{abs} is to be achieved. Therefore, we use the following expression

$$\sigma_{abs} = \pi(R + \bar{\lambda})^2 \times T \qquad \textbf{(2)}$$

Here, T is the transmission coefficient.

For certain nuclei, if T = 1, then the nuclei are called completely black, if T=0, then the nuclei are called completely transparent.

Now, agreement between the calculated and experimental values of σ_{abs} is achieved in all cases considered in this work by giving different numerical values to T (0 < T < 1), and then getting by multiplying the calculated values of σ_{abs} by these values.

Table 1: The values of proton-nucleus absorption cross-sections, σ_{abs} (mb), for 20 GeV/c ≤ p_{mom} ≤ 60 GeV/c are shown in table

Nuclei	P (GeV/c)	σ_{abs} (Exp.) (mb)	σ_{abs} (Calc.) (mb)	T	σ_{abs} (Calc.). T (mb)
Li^7	20	175±2	260.30	0.672	174.92
	30	174±2	259.72	0.669	173.75
	40	175±2	259.54	0.674	174.92
	50	174±2	259.36	0.670	170.42
	60	176±2	259.17	0.679	175.98
Be^9	20	209±3	307.42	0.679	208.93
	30	210±3	306.83	0.684	209.87
	40	210±2	306.66	0.685	210.06
	50	210±3	306.44	0.685	209.91
	60	216±2	306.24	0.705	215.90
C^{12}	20	247±2	373.52	0.661	246.90
	30	247±3	371.35	0.665	246.94
	40	246±2	370.71	0.663	245.78
	50	247±3	370.49	0.666	246.74
	60	252±4	370.27	0.680	251.78

The data of other five nuclei (i.e. Al^{27}, Cu^{63}, Sn^{118}, Pb^{207}, and U238) is not shown in this table.

Figures

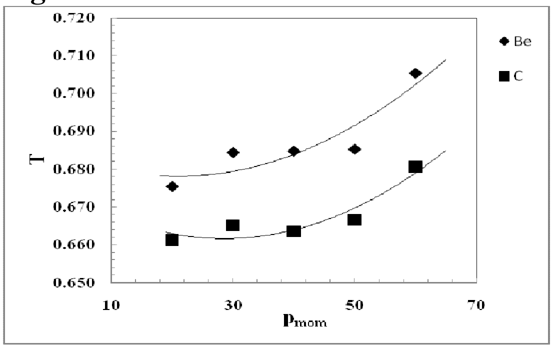

Fig. 1: The variation of Nuclear Transparency of 'Be', and 'C' nuclei with proton momentum (p_{mom}) ranging from 20 GeV $\leq p_{mom} \leq 60$ GeV.

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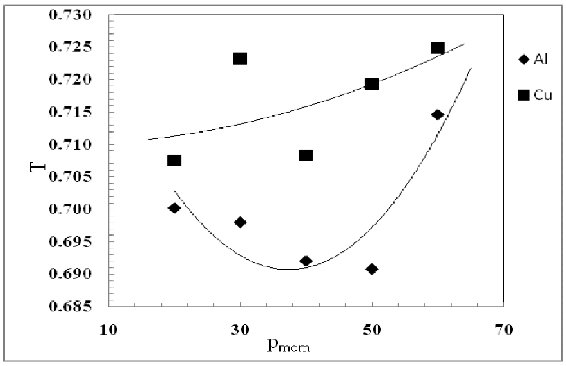

Fig. 2: The variation of Nuclear Transparency of 'Al' and 'Cu' nuclei with proton momentum (p_{mom}) ranging from 20 GeV $\leq p_{mom} \leq 60$ GeV.

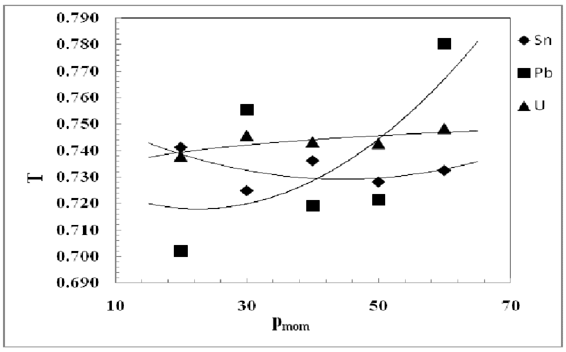

Fig. 3: The variation of Nuclear Transparency of 'Sn', 'Pb' and 'U' nuclei with proton momentum (p_{mom}) ranging from 20 GeV $\leq p_{mom} \leq 60$ GeV.

Result and Discussion

The result of this work is represented in the fig. (1-2). Therefore in figure (1) the variation of nuclear transparency of 'Be' and 'C' nuclei with proton momentum (p_{mom}) has shown. While the figure (2) represents the variation of nuclear transparency of 'Al' and 'Cu' nuclei with proton momentum (p_{mom}) has shown. In the figure (3) the variation of nuclear transparence with proton energy between 20 GeV $\leq p_{mom} \leq 60$ GeV has shown.

From all three figures (1, 2 and 3) it is apparent that at higher values of momentum, nuclei shall be only partially black to proton. The nuclei are not likely to become completely transparent to proton no matter how high momentum it is given.

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