Fitting of Absorption Cross-section for Pion – Nucleus Collisions

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Introduction

We present here a new approach to calculate the absorption cross-sections for pions on target nuclei. An attempt is made to modify the black disc formula $\sigma_{abs} = \sigma_0 A^{\alpha}$, based on the Glauber multiple-scattering model. Pion absorption cross-section is calculated for three groups of targets viz. light nuclei, intermediate nuclei and heavy nuclei.

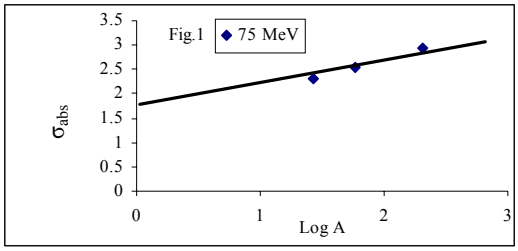
The absorption cross-section may be considered as the difference of the total cross-section and the elastic cross-section. The mechanism of the absorption of hadrons with complex nuclei has been studied by several physicists [1-11]. Different fittings and parameterizations were proposed for the absorption cross-section of hadrons. The dependence of absorption cross-section upon the atomic weight of the target 'A' is well described by the power function $\sigma_{abs} = \sigma_0 A^{\alpha}$, where, σ_0 and α are two adjustable parameters depending upon the value of the total cross-section for particle interactions with nucleon [8-14]. For obtaining better fit of the experimental data the values of the parameter σ_0 and α are adjusted by the method of least squares.

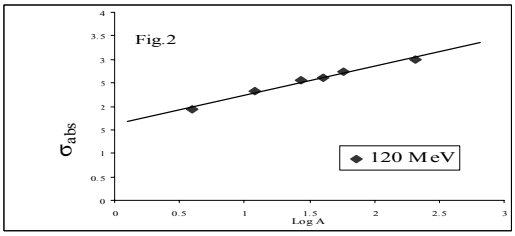
Parameterization of Absorption Cross-section

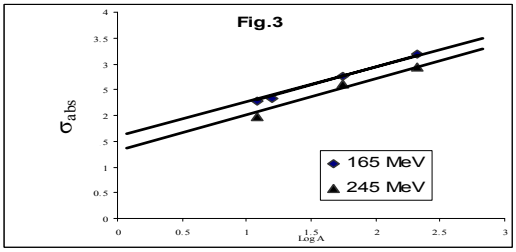
There are some limitations in the most widely used above parameterization. The parameterization has been done over limited energy range, however, the fitting of σ_{abs} over the entire energy range, following the same procedure, has not come to our notice: The fact that the two parameterization of the two adjustable parameters leaves room for ambiguity and also makes the task laborious and time consuming. To reproduce the experimental data, one can fix the value of either of the two parameters and vary the value of the other parameter or the values of both the parameters can be varied. This introduces ambiguity. Also the earlier parameterization has limited applicability. The average values of σ_0 and α obtained for a particular set of nuclei are applicable only to that set of nuclei for one value of the incident energy. These values can not be used to discern any systematic, regular behavior of σ_{abs} over entire range of energy and also for different nuclei. The ambiguity and the limited applicability, as discussed above, reduce the utility of the parameterization.

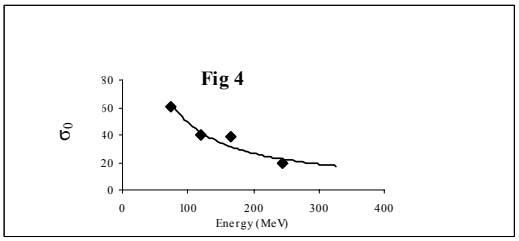
Table1: Values of Parameters σ_0 and α

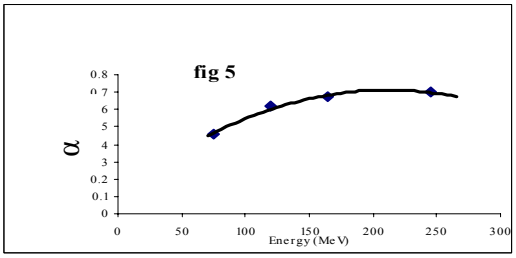
E MeV	Target Nuclei	σ_{abs} Exp.	$\sigma_{abs.}$ Cal.	σ_0	α
75	He (4) C (12) Al (27) Ar (40) Fe (56) Ni (58) Pb(208 Bi(209	------- ------- 210±50 ------- ------- 360±90 900±225 --------	114.2 189.2 275.1 329.5 384.6 390.9 703.5 705.0	60.39	0.46
120	He (4) C (12) Al (27) Ar (40) Fe (56) Ni (58) Pb(208	84.4±14.2 205±50 350±90 393±21 -------- 540±135 1010±250	94.45 186.6 307.9 393.8 484.17 495.7 1091.8	39.99	0.62
165	C (12) O (16) Al (27) Fe (56) Ni (58) Pb (208 Bi(209)	194±36 215±48 -------- 577±87 ------- -------- 1585±280	203.0 246.2 349.5 569.9 590.2 1372.7 1377.2	38.42	0.67
245	He (4) C (12) Al (27) Fe (56) Ni (58) Bi(209)	------- 95 ±32 ------- 411±70 ------- 854±66	52.67 113.6 200.5 341.1 342.37 839.9	19.96	0.70











An analysis of the available data on σ_{abs} is made in the present-work with a view to finding whether, (i) the σ_{abs} data can be parameterized at low as well as high values of incident energy by the same expression, (ii) the procedure of fitting the data can be simplified, (iii) the ambiguity can be eliminated, (iv) any regular feature of σ_{abs} as a function of nuclear mass and incident energy can be inferred.

The fitting of σ_{abs} starts with the earlier parameterization $\sigma_{abs} = \sigma_0 A^{\alpha}$, which can be written as-

$$\log \sigma_{abs} = \alpha \log A + \log \sigma_0$$

This is the equation of a straight line. The slope of the line gives the value of the parameter α, while the intercept of the line provides that of the parameter σ_0.

Results and Conclusions

The results of the present parameterization are presented in the following Table.1 and Figs. (1-5) and found to be unambiguous and applicable for the entire energy range.

In the present word the interactions of positive pion with target nuclei is considered at incident energies 75 MeV, 120 MeV, 165 MeV and 245 MeV. The experimental data is taken from different references [1-11]. Using the experimental data, the graphs between log A and $\log\sigma_{abs}$ are drawn and the values of the parameters α and σ_0 are calculated for different values of incident energies, and are mentioned in the table: 1. the variations of σ_0 and α as a function of incident energy are shown in the fig. 4 and 5 respectively.

In this work, we conclude that the present fitting of the absorption cross-section of pions interactions with complex nuclei; minimize the limitations of earlier parameterization as mentioned earlier.

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