ANOMALOUS INTERACTION MEAN FREE PATH OF SECONDARY PARTICLES Emitted IN C$^{12}$-EMULSION INTERACTION AT 4.5 GeV/n.

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ABSTRACT

A study on the interaction mean free path of the relativistic alpha particles emitted from the interaction of 4.5 GeV/nucleon with the emulsion nuclei has been made. The tracks were followed systematically through the stack. The detail measurement shows clearly that the interaction mean free path is anomalously shorter for a few centimeters after their emission. The results have been compared with other results obtained from both accelerator and cosmic ray data.

1. Introduction

Evidence for anomalously short interaction mean free paths of projectile fragments of different charges, from high energy heavy ion collisions has reported been observed in cosmic ray studies (Judek 1968). This has further been supplemented by the observation of similar effects of projectile fragments from 2.1 GeV/nucleon O$^{16}$ beam and 1.88 GeV/nucleon of $^{56}$Fe beam from accelerators used in emulsion experiment. Friedlander et al (1980). In our experiment, the evidence of such anomalous reaction mean free path of secondary alpha particles in particle fragments emitted from interaction of C$^{12}$ beam of energy 4.5 GeV/nucleon in emulsion are being looked for. Our results
based on observations can be summarized as

a) The interaction mean free path measured at different path lengths from their point of emission are different;

b) that the interaction mean free path shows a definite increase in value with the increase in path length interval;

c) that the average interaction mean free path is comparable with the values obtained by Judek (1968) for secondary alpha particles emitted from stars produced by nuclei (3 ≤ z ≤ 9) from cosmic radiation;

d) that the interaction mean free path in the path length region 0-4 cm is lower in each range as compared with the value 21.9 ± 3.6 cm generally observed for α-particles emitted at very small angles w.r.t. the direction of the incident beam.

2. Experimental detail

The observations were made in a stack of 10 plates of Ilford G-5 emulsions exposed to C^{12} beam at 4.5 GeV/n. Each plate was scanned by the track method by using Leitz Ortholux microscope. The relativistic α-particles emitted from the primary interaction within a very small forward cone were followed after being identified by their distinct grain density from plate to plate. In a well lined-up emulsion stack there is generally little doubt that the same track has been picked up in the next plate. The tracks were followed until they interacted or left the plate. Tracks of slower particles with similar ionization could be eliminated from the observation in grain densities along their track. An interaction was accepted if at least one additional track was emitted and if there is an unusual change of direction is observed. Whenever stars are produced by the secondary α-particles they were found to have the same characteristics of nuclear interactions.

The mean interaction lengths for the particle of fixed charge value were calculated as a function of distance from the interaction from which they were emitted. The tracks were subdivided into successive 1-cm intervals. All the
track segments lying within the same interval were added together and divided by the total number of interactions observed in that interval. For a homogeneous beam of nuclei of charge $Z$, the free path $\lambda_Z$ is defined via the distribution of interaction distance $x$

$$f(x) \, dx = \frac{e^{-x/\lambda_Z}}{\lambda_Z} \, dx$$

A maximum-likelihood estimate is obtained from

$$\lambda = \frac{S_i}{N}$$

where $S_i$ is the total length of both interesting and non-interacting tracks followed in the $i$th interval until $N$ reactions have been observed. (The value of $N$ in our case is not however very large at fixed $Z$).

3. Results

The variation of mean free path value with the increase in track length interval is shown in Fig. 1.

The dotted line represents the average mean free path of secondary alpha-particles as reported by Judek (1968) and the dots, the observed mean free path in this experiment.

Thus this analysis indicates clearly that the interaction mean free path of the relativistic alpha-particles emitted from the interaction of 4.5 GeV $^6$Li with the emulsion nuclei is anomalously short.

![Fig. 1](image)

Fig. 1: Plot of interaction mean free path of the $\alpha$-particles against distance.
References