MEAN FREE PATH OF 4.5 BEV π–MESONS IN ILFORD G5 EMULSIONS*

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(Received October 1959),

The experimental value of the mean free path for the nuclear interaction of artificially produced π-mesons of 4.5 Bev. energy has been found to be 33.5±3.5 cm. Ilford G-5 emulsions, 400 microns thick, were exposed to the high energy meson beam, the measurements being made by the so-called "Line Scanning" or "the following along the track" method. Our result is comparable with earlier data for mesons with energies upto 3 Bev.

Introduction

Much progress was made in our knowledge of the properties of π-mesons since their discovery in 1947. Many facts were first established by cosmic ray experiments. The possibility of artificially producing π-mesons in large numbers has opened the field to more refined means of experimentation. These have given us precise informations on many properties of these mesons which are at least qualitatively understood on a theoretical basis.

Experiments on the nuclear interaction of artificially produced π-mesons have been carried out at several laboratories, viz., Columbia, Rochester, Berkeley and Chicago. But it appears that there exists definite disagreement between the experimental resluts obtained at these laboratories. Since the study of the interactions between π-mesons and nuclei are considered to be so important for a clear understanding of the problem of nuclear forces, it was felt desirable to carry out further investigations on the problem. The main object of the present work has been to obtain the experimental value of the mean free path for this interaction using π-mesons of a higher energy, viz. 4.5 Bev.

Experimental Technique

(*i*) *Exposure of Plates.*—Ilford G-5 emulsions, 400 microns thick, were exposed to the high energy meson beam of the Berkeley Bevatron. The beam with an average energy of 4.5 Bev. was allowed to hit the end of the stack of emulsions in a strip 3″ wide in the centre of the stack. The negative pions were selected by an analysing magnet from the secondary particles emitted from a target at 90° to the direction of the proton beam. The emulsions were placed with the 3″ side parallel to the pion beam.

(*ii*) *Microscopic Measurements.*—Measurements were made by the so-called "Line Scanning" or "the following along the track" method. The plate was placed on the microscope stage in such a way that the π-meson tracks were all parallel to the X-axis, so that the X-motion of the stage could be used to measure the length of each track scanned. The beginning of each track was made coincident with some point on one side of the rectangular mesh, that is, the field in view, and the track was followed by advancing the X-motion of the stage in steps and varying the depth of focus until the end of the track was reached. The distance between the two readings at the beginning and the end as read on the vernier scale of the microscope stage gives the length of the track scanned. The stage was then brought back to the original point of starting and was then moved in the Y-direction to the next field of view and the tracks were followed as before. The operations were repeated until a sufficient length of the tracks was measured.

It was observed that tracks occasionally collided with emulsion atoms and produced nuclear disintegrations, more popularly termed as "Stars". The magnification employed all through in the present investigation was 45 × 12, that is, a X45 objective was used in conjunction with a X12 eyepiece.

Since all the π-tracks were approximately flat, the angle of dip was not taken into account.

Experimental Results and Conclusions

In scanning a total length of 32.85 metres of π-meson tracks, 98 interactions were found. All these interactions were nuclear disintegrations of emulsion nuclei initiated by the 4.5 Bev. π-mesons.

No event of elastic scattering or disappearance in flight was observed. Hence the mean free path for nuclear interaction was found to be 33·5±3·5 cm. The ratio of the geometrical to the observed mean free path was thus obtained as 1.34.

From Table 1, in which the known data for π-mesons of various energies are collected, it can

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TABLE 1.—MEAN FREE PATH OF π--MESONS IN ILFORD G5 EMULSIONS.

Energy range	M.F.P.	Observed value/ Geom. value	Authors
70- 80 Mev.	20 ±2.6 cm. of emulsion	1.00	Bernadini et al.
60- 90 Mev.	22.1±4.4 ,, ,,	1.10	,, ,,
100-110 Mev.	18.5±2.0 ,, ,,	0.90	,, ,,
30- 40 Mev.	22.1±2.7 ,, ,,	0.93	Bradner & Rankin
210 Mev.	25.7±1.6 ,, ,,	1.03	Morrish
750 Mev.	38.5±2.2 ,, ,,	1.54	Blau & Oliver
3 Bev.	35.5±5 ,, ,,	1.42	Schien et al.
4.5 Bev.	33.5±3.5 ,, ,,	1.34	Present work

be seen that the mean free path is very nearly geometrical and remains constant in the energy range 30-210 Mev. However, it is found that it rises to a value of 38.5±3.2 cm. at 750 Mev. as observed by Blau and Oliver, while Schien, Haskin and Glasser obtained a value of 35.5±5 cm. for 3 Bev. π-mesons. This compares well with our result, viz., 33.5±3.5 cm. for 4.5 Bev. π-mesons, making allowance for the experimental and statistical errors involved in the measurements. Thus it can be seen that at very high energies the mean free path of π-mesons in Ilford G5 nuclear emulsions remains constant at about 36 cm., which is significantly higher than the geometrical value, viz., 25 cm.

Acknowledgements

The authors acknowledge their grateful thanks to Professor C.F. Powell of the University of Bristol, England, for kindly lending the plates on which measurements were made. The plates were exposed to pi-mesons at the Lawrence Radiation Laboratory, Univeristy of California, Berkeley, California.

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Note Added in Proof.—It is of interest to add that in a recent experiment with 14 GeV/c π-mesons from the CERN proton synchrotron, the mean free path of pions in emulsion has been found to be 32.8 ± 1.5 cm. (private communication from Lock and Herz, to be published soon in Nuovo Cimento).