NOTAS DE FÍSICA
VOLUME VIII
Nº 20

ON THE BEHAVIOUR OF THE MULTIPLE SCATTERING CONSTANT, K, FOR NUCLEAR EMULSION, AT LARGE CELL SIZES

by

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CENTRO BRASILEIRO DE PESQUISAS FÍSICAS
Av. Wenceslau Braz, 71
RIO DE JANEIRO
1961

Notas de Física - Volume VIII - Nº 20

ON THE BEHAVIOUR OF THE MULTIPLE SCATTERING CONSTANT, K, FOR NUCLEAR EMULSION, AT LARGE CELL SIZES*

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(Received November 10, 1961)

In a previous paper Hossain _et al_[1] have reported results on multiple scattering measurements on the tracks of high energy particles in nuclear emulsions. Indications were found of a possible discrepancy between the theoretically expected values of the mean scattering angle and that found experimentally at cell sizes, t, greater than 1 cm.

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* Submitted to Nuovo Cimento.

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In this letter we (a) present the results of measurements on a further sample of tracks produced by negative pion of 16.2 GeV/c momentum, which confirm the measurements, made in the same stack, reported in (1); (b) present the results of measurements on the tracks of 8.2 GeV/c muons, which also show the same effect as was obtained from the measurements on the pion tracks; and (c) calculate the value of the scattering constant, K, needed to fit our data for values of t greater than 1 cm.

The experimental procedure has already been described[1]. The microscope used was a Koristka type R-4. The total noise (stage, reading and grain noise) was $\sim 0.2\ \mu$, which for $t > 1$ cm is negligible compared with the signal ($\gtrsim 8\mu$) from the multiple Coulomb scattering. A 30 × objective was employed giving a field of view of 150μ width. A basic cell size of 1 cm was used for the measurements and values of the mean second difference $\bar{D}$ for 2 cm and 3 cm cell sizes were obtained using non-overlapping cells.

We have considered carefully the question of bias in our experimental data. Due to the low-power objective used no tracks had to be abandoned due to a large angle scattering along its path. All the tracks that were measured have been included in the results. The "flat chamber effect" (caused by the finite thickness of the emulsion) is negligible at the scattering angles with which we are concerned (see Menon et al[2]). The low resolution of the optical system we have used could only have the effect of adding noise to the measured $\bar{D}$ and hence increasing the experimental value of K. This effect is seen to be small since within statistical errors the present results from the pion stack agree with those reported in (1), which were obtained using a 55 × objective.

The scattering constant K was calculated from the experimental value of the mean second difference $\bar{D}$, using the known momenta of the beam particles, and assuming spurious scattering to be zero. Any correction for a finite amount of spurious scattering will only make the calculated values of K smaller.

The values of $\bar{D}$ and of K are given in TABLE I and Fig. 1. The value of $\bar{D}$ for 2 cm cells in the pion stack ($8.12 \pm 0.35\mu$) is in agreement with that obtained from the previous measurements and reported in (1), viz. $7.9 \pm 0.6\mu$. In Fig. 1 are also plotted the expected variations of K with cell-size following the Williams[3] theory for a point charge nucleus (curve 1), and his correction for the finite size of nucleus (curve 2). We have taken Williams' curves from the paper of Voyvodic and Pickup[4].

For our energy range, the measurements in the region of cell-sizes up to ~1 cm are likely to overestimate the value of $\bar{D}$ by $\lesssim$ 10% because of the influence of spurious scattering, and so we have not used them for the purpose of studying the behaviour of the scattering constant.

The experimental points obtained at 1 mm, 1.5 mm and 2 mm cell-sizes by Brisbout et al[5], which are free from spurious scattering since they were obtained by relative scattering measurements, are also given in Fig. 1.

Our data for 2 cm and 3 cm cell-sizes and the Brisbout points suggest that the simplest assumption for practical purposes is to take a constant value of scattering constant K = 27.6 ± 0.6

(the weighted average of the experimental points in Fig. 1) in the cell-size range 1 mm to 3 cm. This value of K = 27.6 is, at the 2 cm cell-size, about 15% lower than curve 1 and about 11% lower than curve 2.

Cooper and Rainwater have calculated the angular distribution for multiple scattering of 1 GeV μ mesons in 1 cm of lead[6]. The average angle is about 3% lower than the Molière calculation (which is equivalent to the Williams' point-charge calculation).

Olbert's calculation[7] gives an average angle 4% lower than Molière's prediction. The points of Cooper and Rainwater and of Olbert are plotted in Fig. 1, at a cell size of 6 cm of emulsion, which is approximately equivalent to 1 cm of lead.

The agreement between the muon and pion data suggest that, within the errors of the measurements, the contribution of nuclear forces is not important in the phenomena discussed in this paper. The introduction of extended charge of nucleus brings the theoretical curve for K nearer to the experimental points. Possibly, some changes in the statistical treatment of the theory of multiple Coulomb scattering will further contribute to the better fitting to our data.

ACKNOWLEDGEMENTS

Our grateful thanks are due to Dr. W. O. Lock and Dr. G. Vanderhaeghe for many fruitful discussions during the course of the work. The emulsions used were exposed in muon and pion beams set up at the CERN PS by the Group of Dr. B. D. Hyams and by Dr's H. Bingham, B. de Raad and R. G. P. Voss respectively. We are indebted to them and to the PS Machine Division for their kind co-operation. The emulsions exposed in the pion beam were processed by Mr. M.A.Roberts, Mr. R. Sterchi and Dr. G. Vanderhaeghe. We are indebted to Dr. M. Gailloud and his colleagues at the Ecole Polytechnique, Lausanne, for the loan of their emulsions which they exposed in the muon beam.

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TABLE I

Cell-size (mm)	π^- mesons (16.2 GeV/c)		μ-mesons (8.2 GeV/c)	
	$\bar{D}$ (in μ)	K	$\bar{D}$ (in μ)	K
20	8.12 ± 0.35	26.6 ± 1.15	16.58 ± 1.5	27.5 ± 2.5
30	14.20 ± 1.00	25.4 ± 1.8		

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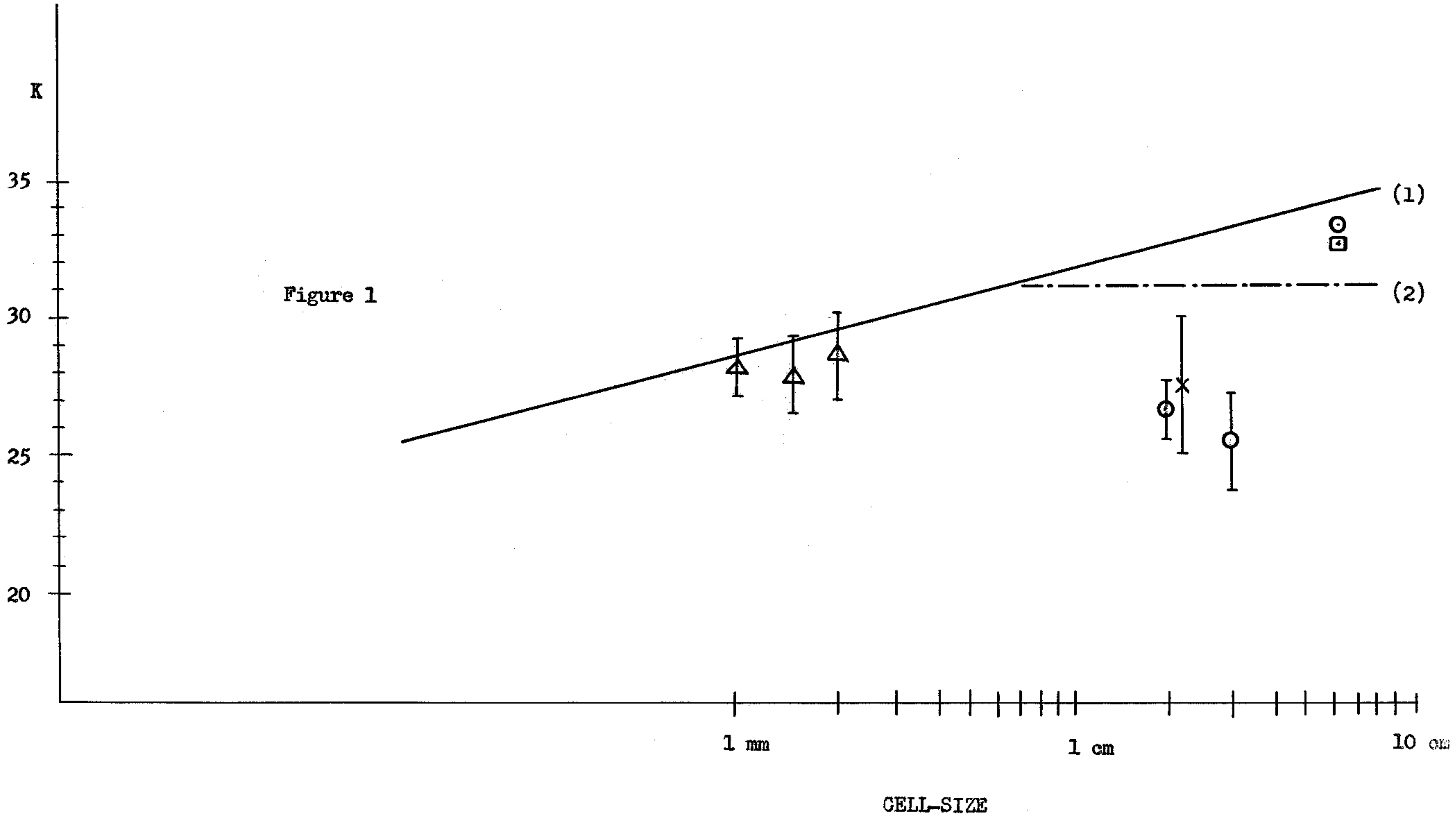

Figure 1

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