Search for anomalons in interactions of neon-22 nuclei with emulsion nuclei at 4.1·A GeV/c

B. P. Bannik, Yu. A. Batusov, L. N. Bokova, A. Vokalova, O. M. Kuznetsov, V. V. Lyukov, O. V. Piskaleva, K. D. Tolstov, V. I. Tret'yak, and G. S. Shabratova
Joint Institute for Nuclear Research

N. P. Andreeva, Z. V. Anzon, V. I. Bubnov, A. Sh. Gaĭtinov, L. E. Eremenko, G. S. Kalyachkina, É. K. Kanygina, and I. Ya. Chasnikov
Institute of High-Energy Physics, Alma-Ata

M. Gitsok, A. Marin, H. Roshu, M. Haiduk, and D. Hašegan
Central Institute of Physics, Bucharest

I. Bobodzhanov, V. A. Leskin, A. Mukhtarov, and Sh. M. Shermatov
Physicotechnical Institute, Dushanbe

R. A. Khoshmukhamedov
TGMI, Dushanbe

M. Sh. Dzhuranova and Dzh. A. Salomov
Tadzhik State University, Dushanbe

F. A. Avetyan, V. M. Krishchyan, N. A. Marutyan, K.A. Matevosyan, and L. G. Sarkisova
Erevan Physics Institute

F. G. Lepekhin and B. B. Simonov
Leningrad Institute of Nuclear Physics

J. Koraba, M. Korabovi, and E. Silesh
University of Kosice, Czechoslovak SSR

B. Wilcincka, V. Volter, B. Vosek, A. Olshecki, and R. Holyncki
Institute of Nuclear Physics, Krakow

V. A. Antonchik, V. A. Bakaev, A. V. Belousov, S. D. Bogdanov, and V. I. Ostroumov
Leningrad Polytechnical Institute, Leningrad

V. G. Bogdanov, V. A. Plyushchev, and Z. I. Solov'eva
RI, Leningrad

M. I. Adamovich, V. G. Larionova, G. I. Orlova, N. A. Salmanova, M. T. Tret'yakova, and S. P. Kharlamov
P. N. Lebedev Physics Institute, Academy of Sciences of the USSR, Moscow

S. A. Azimov, A. Abduzhamilov, Sh. Abduzhamilov, S. Gadzhieva, K. G. Gulamov, M. Dzhuraev, A. Zhumanov, N. S. Dukicheva, D. Mirkhodzhaeva, V. Sh. Navotnyĭ, V. I. Petrov, N. Sh. Saidkhanov, L. N. Svechnikova, and L. P. Chernova
Physicotechnical Institute, Tashkent

 0021-3640/84/040219-04$01.00

O. Babaev, U. G. Gulyamov, R. U. Khalmatova, and G. M. Chernov
Institute of Nuclear Physics, Tashkent

A. V. Burduli and N. I. Kostanashvili
Tbilisi State University, Tbilisi

L. Sérdamba, R. Togoo, and D. Tuvdendorzh
IFT, Ulan-Bator

(Submitted 13 January 1984)
Pis'ma Zh. Eksp. Teor. Fiz. **39**, No. 4, 184–186 (25 February 1984)

The mean free path before an inelastic interaction of relativistic fragments of neon-22 nuclei with emulsion nuclei at a momentum of 4.1·A GeV/c is studied as a function of the distance traversed by the fragments. No such dependence is found for fragments with charges from 3 to 9.

It was found in Refs. 1–3 that relativistic fragments of projectile nuclei have an anomalously short mean free path λ over the first few centimeters away from the vertices of the primary interaction. The relativistic fragments responsible for this effect have been termed "anomalons." The statistical base in Refs. 1–3 was too small for a separate study of λ for fragments with a specific charge (z), so the relation $\lambda(z) = Az^{-b}$ was used to combine the data on the fragments of various charges. In this appraoch, one determines a charge-independent parameter $\Lambda^*(X)$, instead of the individual values $\lambda^*(z, X)$, where X is the distance from the point at which the relativistic fragment is produced. In this letter we report preliminary results of a study of the mean free paths of fragments emitted from the interactions of neon-22 nuclei with nuclei of a photographic emulsion at a momentum of 4.1·A GeV/c. Stacks of BR-2 emulsion, 10×20 cm in size, were bombarded by a beam of neon nuclei on the proton synchrotron of the Joint Institute for Nuclear Research, Dubna. The interactions were sought by the method of following a track and by area scanning. Fragments of charge $z \geqslant 3$ emitted from the interactions caused by both primary nuclei and relativistic fragments were traced until an interaction or until escape from the stack. The charge was determined for each fragment, and the distance traversed was measured. For the relativistic fragment of each charge, the mean free path was found from $\lambda^* = L/N$, where L is the total measured path traversed, and N is the number of interactions found. The results are listed in Table I.

A total of 4991 interactions of relativistic fragments were detected This statistical base was sufficient for a separate test for each charge of whether λ^* is a function of X, the distance from the fragment emission point. The results are shown in Fig. 1. We see no hint of an anomalously short mean free path over the first few centimeters after the production of the fragments. In addition, we carried out a standard statistical analysis of the distribution of distances (l_i) traveled by the fragments of a given charge before an interaction. We tested the null hypothesis—that the experimental data set is a sample of a general set with an integral distribution function $F(l) = 1 - e^{-l/\lambda^*}$. Here λ^* is a consistent estimate of the actual value of the mean free path. For the data not

TABLE I.

Fragment charge	3	4	5	6	7	8	9
Number of fragments traced	1127	1037	1205	1533	1493	1517	959
Number of interactions	547	504	650	841	855	966	628
λ^* (cm)	14,1 ± .6	14,9 ± .6	13,4 ± .5	13.8 ± .4	12.7 ± ,4	10,7 ± .3	9,9 ± .3
$\lambda^*(X < 3$ cm)	13.3 ± .9	13.5 ± .9	14.1 ± .9	14.1 ± .8	12,6 ± .7	10,1 ± .5	9,0 ± ,5
$\lambda^*(X > 3$ cm)	14.4 ± 0.7	15.7 ± 0.8	13,1 ± 0,6	13,6 ± 0.5	12.8 ± 0.5	11,1 ± 0,4	10.5 ± 0.5

broken up into histograms we used the Kolmogorov and Smirnov-Cramer-Mises Methods. For the data grouped in cells on the basis of l_i, with an identical expected number of interactions, we used the χ^2 test and the series test.[4] The results are given in Table II.

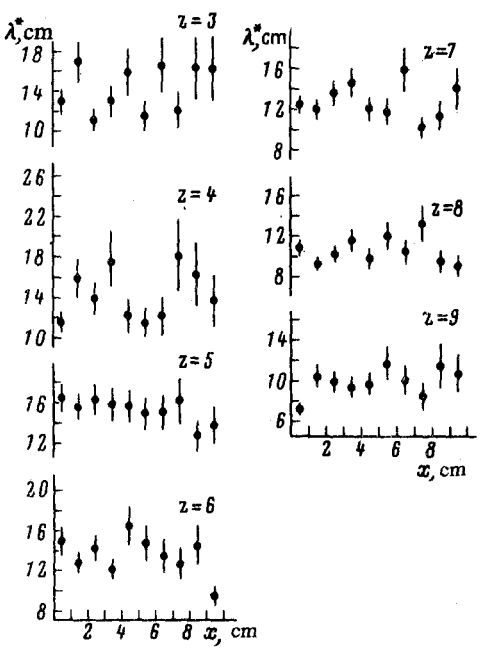

FIG. 1. Mean free path as a function of the distance traversed by the relativistic fragments from the point of the primary interaction.

TABLE II.

Fragment charge	3	4	5	6	7	8	9
$\sqrt{N}\Delta_{max}$	0.59	0.61	1.00	0.76	1.00	0,98	0.88
$N<\omega^2>$	0.02	0.06	0.07	0.05	0.10	0.10	0.10
χ^2/DE	0.48	0,83	1.24	0.51	0.98	1.12	0.96
R_e	8 ± 1.4	7 ± 1.5	5 ± 1.5	6 ± 1.5	7 ± 1.4	6 ± 1.4	4 ± 1.5
R_t	5.8	6.0	6.0	6.0	5.8	5.8	6.0

The critical regions at a confidence level of $\alpha = 0.05$ are as follows: The Kolmogorov criterion, $\sqrt{N}\Delta_{max} > 1.36$; the Smirnov-Cramer-Mises criterion, $N<\omega^2\geqslant 0.461$; and $R_e < R_t$ in the series criterion, where R_e and R_t are the experimental and theoretical numbers of series, respectively. We see that the null hypothesis is not rejected.

Conclusion. In summary, this study of the mean free paths before inelastic interactions of fragments of neon-22 nuclei with charges $3\leqslant z\leqslant 9$ in nuclear emulsions at a momentum of 4.1·A GeV/c has shown that there is no significant change in this mean free path with distance from the primary interaction. The distribution of paths traveled for the fragments of a given charge can be described well (at a confidence level of 0.95) by a simple exponential distribution.

We wish to thank the photochemical staff at the High Energy Laboratory and the proton synchrotron staff at the JINR for their excellent preparation of facilities for bombardment of the emulsion stacks.

[1]E. M. Friedlander *et al.*, Phys. Rev. Lett. **45**, 1084 (1980).
[2]P. J. Jain and G. Das, Phys. Rev. Lett. **48**, 305 (1982)
[3]M. B. Barber *et al.*, Phys. Rev. Lett. **48**, 856 (1982).
[4]W. T. Eadie *et al.*, Statistical Methods in Experimental Physics, North-Holland, Amsterdam, 1971 (Russ. transl. Atomizdat, Moscow, 1976).

Translated by Dave Parsons
Edited by S. J. Amoretty