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DETERMINATION OF CROSS SECTIONS FOR ^{12}C - NUCLEUS INTERACTIONS AT 4.5 GeV/c PER INCIDENT NUCLEON MOMENTUM

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Аксиненко В.Д. и др. **E1 - 12713**

Сечения взаимодействия ^{12}C с ядрами при импульсе 4,5 ГэВ/с на нуклон

На установке со стримерной камерой /СКМ-200/ смонтированной на выведенном пучке дубненского синхрофазотрона, измерены сечения неупругих взаимодействий и сечения рождения отрицательных пи-мезонов во взаимодействиях ядер ^{12}C 4,5 ГэВ/с·нуклон с ядрами C, Ne, Si, Cu и Zr. Точность измерения сечений /с учетом систематических ошибок/-/5 ÷ 7/%. Неупругие сечения хорошо описываются формулой Брадта-Петерса $\sigma = \pi r_0^2 (A_P^{1/3} + A_T^{1/3} - b_0)^2$ с параметрами r_0 =1,30 ферми и b_0 =0,61.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

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Aksinenko V.D. et al. **E1 - 12713**

Determination of Cross Sections for ^{12}C -Nucleus Interactions at 4.5 GeV/c per Incident Nucleon Momentum

Interactions of relativistic ^{12}C nuclei with pure nuclear targets C, Ne, Si, Cu, and Zr have been studied in the SKM-200 streamer chamber. The cross sections have been determined for inelastic interactions, σ^{inel}, and for the emission of at least one negative particle, σ^{neg}. An analysis of possible sources of systematic errors has been performed. A comparison is made with results of other experiments and data obtained earlier by the SKM-200 Collaboration for ^4He-nucleus interactions.

The investigation has been performed at the Laboratory of High Energies, JINR.

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I. INTRODUCTION

Cross-section values for interactions of relativistic ^{12}C nuclei with C, Ne, Si, Cu and Zr nuclei were studied in the experiment carried out with the use of the SKM-200 streamer chamber (200x100x60 cm^3). The experimental setup was placed in a magnetic field and exposed to an extracted beam of ^{12}C nuclei accelerated at the Dubna synchrophasotron. The beam momentum was 4.5 GeV/c per incident nucleon. The solid pure nuclear targets, mounted inside the fiducial volume of the chamber, had the form of thin discs. The streamer chamber was filled with pure neon gas which served also as a target.

A detailed description of the experimental setup and its triggering system has been given elsewhere /1,2/. In this paper only those parameters of the triggering system will be discussed which are important for the cross-section determination.

II. CROSS-SECTION DETERMINATION

In order to obtain a cross-section value, it is necessary to know the ratio of the number of interactions in the target to that of nuclei incident on the target. This ratio can be obtained from the values of N_t and N_c, respectively, where N_t is the number of triggers and N_c the number of particles entering the chamber determined for each target used in the experimnt. The fraction of interactions in a target per trigger (or per picture) was then determined during the scanning.

III. BEAM AND TRIGGERING SYSTEM

The beam used in this experiment consisted of ^{12}C nuclei with a small admixture (5-10%) of ^4He nuclei. Measurements of the energy loss rate, performed with the S_1 and S_2 counters of the downstream telescope (see Fig. 1), made it possible to get rid of the beam contamination with a

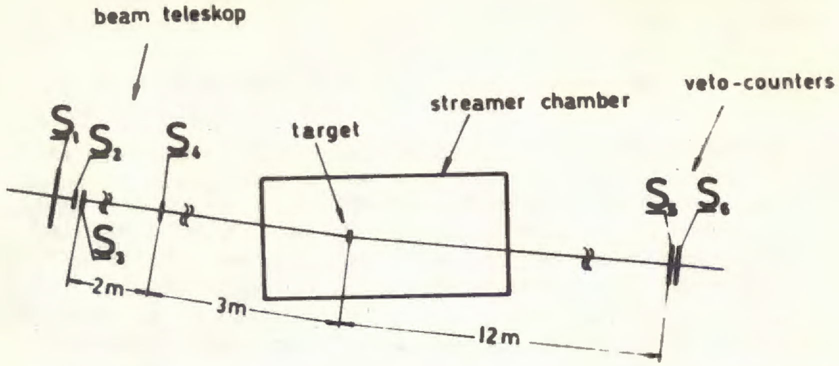

Fig.1. Experimental setup: S_1, S_2, S_3, S_4 - beam telescope; S_5, S_6 - veto counters. Target thicknesses: C - 0.258 g/cm^3, Si - 0.351 g/cm^3, Cu - 0.351 g/cm^3, Zr - 0.267 g/cm^3.

confidence of about 100%. The number of ^{12}C nuclei entering the chamber, N_c, was determined by the $S_1 \ldots S_4$ counters ($N_c = S_1 \times S_2 \times S_3 \times S_4$), while the number of triggers, N_t, was determined by $N_t = S_1 \times S_2 \times S_3 \times S_4 \times \bar{S}_5 \times \bar{S}_6$.

The knowledge of the geometry of our experimental setup, in particular of the form and size of the scintillation counters, and the analysis of the resolution of the dE/dx measurements with the S_5 and S_6 counters, allow one to estimate the fractions of events the fragments of which have hit the veto-counter and thus have escape detection analysis.

IV. POSSIBLE SOURCES OF SYSTEMATIC ERRORS

The following sources of systematic errors in the cross-section determination were analyzed, and appropriate corrections were introduced:

1. The veto-counters are blocked for 20 ns after passing each particle through the system. During this time about 2-4% of interactions can be lost (not registered). The corresponding correction factor is introduced into the cross-section values.

2. A fraction of events is lost due to the triggering of the veto-counter system by a projectile fragment. The analysis of this effect was carried out and allowed one to estimate the values of corrections (about 1-2%) for the cross sections.

3. During the scanning one cannot distinguish a fraction of events (particularly highly collimated events) in the gas filling the target container and/or in the solid target. Corrections for this effect (1-3%) for light and heavy target nuclei, respectively, were taken into account calculating the cross-section values.

4. A fraction of events (corresponding to ^{12}C dissociation into highly collimated fragments) may be lost during the scanning. This effect leads to corrections of about 1% for the cross-section values.

5. An incomplete geometrical overlap of the beam and target may lead to understimating the cross-section values. The estimation of this effect does not lead to any essential correction factors.

The analysis of possible sources of systematic errors in the cross sections makes it possible to introduce appropriate corrections into the results and to estimate the corresponding errors.

V.RESULTS OF THE CROSS-SECTION DETERMINATION

The cross-section for inelastic interactions, σ^{inel}, and for the emission of at least one negative particle, σ^{neg}, have been determined for each target used in the experiment. The results are given in the table. The table also presents our previous results concerning ^{4}He -nucleus interactions at the same momentum per incident nucleon /3/. The errors given in the table include both statistical errors and errors in evaluating the corrections.

The dependence of σ^{inel} values on mass numbers, A_p and A_T is shown in Fig. 2.

The formulas most commonly used for descibing the A-dependence of cross-sections are:

$$1)\ \sigma = \pi r_0^2 (A_p^{1/3} + A_T^{1/3} - b_0)^2 , \qquad (1)$$

proposed by Bradt and Peters /8/, and

$$2)\ \sigma = \pi r^2 (A_p^{1/3} + A_T^{1/3} - \beta (A_p^{-1/3} + A_T^{-1/3}))^2 , \qquad (2)$$

proposed by Vary (see ref. /9/).

Table

Incident nucleus	Cross sections (in mb)	Targets							
		^{6}Li	^{12}C	^{20}Ne	^{27}Al	^{28}Si	^{64}Cu	^{91}Zr	^{207}Pb
^{12}C	σ^{inel}		805±30	1100±60		1200±80	1770±90	2025±120	
	σ^{neg}		570±25	795±40		850±50	1310±80	1630±100	
^{4}He	σ^{inel}	320±15	450±20	615±40	720±30		1150±50		2400±170

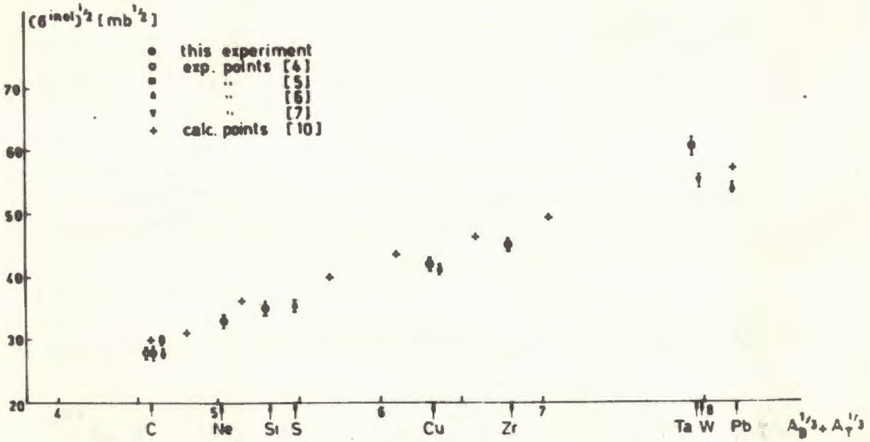

Fig.2. The dependence of the cross-section for inelastic ^{12}C -nucleus interactions on the target mass number, A_T.

O - data from (4) at 4.2 GeV/c per incident nucleon

□ - data from (5) at 2.9. " " " "

Δ - data from (6) at 2.9 " " " "

∇ - data from (7) at 2.9 " " " "

● - this experiment at 4.5 " " " "

+ - values calculated in /10/, see text.

The only discrepency occurs in the case of the cross-section value for $^{12}C-^{181}Ta$ interactions /4/, and therefore this value has not been taken into account when fitting eqs. (1) and (2) to experimental data.

Best fit values of the parameters r_0 and b_0 (eqn. (1)) for the experimental data showing Fig. 2 are r_0 =1.30+/= =0.01 and b_0=0.61+/-0.01, while those for the parameters r and β eqn. (2)/are:

$$r = 1.25+/-0.01 \qquad \text{and } \beta = 0.53+/-0.04.$$

There are known several attempts to describe the A-dependence of the cross-section values, mostly based on the Glauber-type models. The calculations give usually satisfactory form of the dependence, while the absolute values of the cross-sections often fail to be consistent with experimental values. An example of the results of such a theoretical approach /10/ is shown in Fig. 2. The discrepancies such as seen in Fig. 2, in our opinion, may be due to the fact that it is difficult to unify the definitions of inelastic cross-section in the nucleus-nucleus interactions used in a theoretical model and that used in the experiment.

REFERENCES

1. Anikina M.Kh. et al. JINR, 13-9030, Dubna, 1975.
2. Abdurakimov A.Kh. et al. Pribory Tekhniki i Eksperimenta, 1978, 5, p. 53.
3. Anikina M.Kh. et al. JINR, P1-10592, Dubna, 1977.
4. Abdrakhmanov E.O. et al. JINR, E1-12548, Dubna, 1979.
5. Jaros J.A. et al. Preprint LBL-7509, 1977.
6. Lindstrom P.J., Greiner D.F., Heckman H.H. Bull. Am. Phys. Soc., 1972, 17, p. 488.
7. Cheshire D.L. et al. Phys.Rev., 1974, D10, p. 25.
8. Bradt H.L., Peters B. Phys.Rev., 1950, 77, p. 54.
9. Heckman H.H. et al. Phys.Rev., 1978, C17, p. 1935.
10. Andreev I.V., Khein L.A. Jad.fiz., 1978, 28, p. 1499.

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