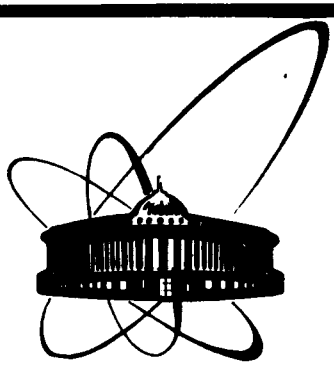

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INELASTIC SCATTERING OF 8.9 GeV/c DEUTERONS ON CARBON

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I. Reactions with relativistic deuterons, in which the deuteron is not destroyed, are of interest due to the possibility of eliciting some features of the deuteron structure and the mechanism of its inelastic interaction, when momentum transfers are large in comparison with the momentum of the intranucleus Fermi motion of nucleons. In particular, such features can be due to multiquark state admixtures in nuclei and nucleon excitations [1,2].

The deuteron appears to lose, with a significant probability, a large fraction of its kinetic energy without destruction despite a small binding energy of the deuteron. Our detailed measurements of the inelastic $dC \to dX$ reaction show that a fast decrease of the cross section at relatively small 4-momentum transfers $|t| \lesssim 0.2$ GeV^2/c^2 is replaced by a "plateau" when passing to the region $0.2 \lesssim |t| \lesssim 2.5$ GeV^2/c^2.

Section 2 contains a short review of the experimental procedure and data processing and tables of the obtained invariant cross sections of the inclusive $dC \to dX$ reaction depending on the longitudinal momentum lost by the deuteron, scattered with a zero mean transversal momentum. In section 3 the results are compared with the data from refs.[5,6] obtained under conditions similar to those of ours. The comparison is made in terms of t-variable.

II. Experimental procedure and data processing.

The experiment was performed on a 8.9 GeV/c deuteron beam extracted from the Dubna synchrophasotron during a time of (0.3÷0.5) sec. The setup (fig.1) worked on-line with an EC-1010 computer. A detailed

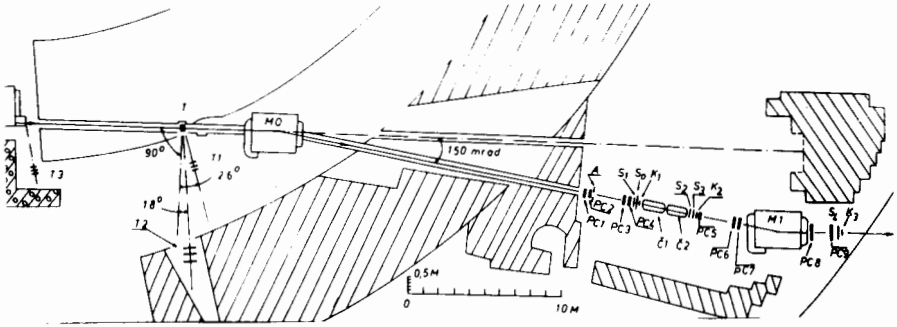

Fig.1. The experimental layout on the slowly extracted beam of the Dubna synchrophasotron. A,Ki,Si,Ti-scintillation counters, $\check{C}_1$,$\check{C}_2$-threshold Cherenkov counters, PC-proportional chambers, T-carbon target (30x140x21 mm^3), MO-bending magnet, M1-analyzing magnet. The particle deflection takes place in an XZ plane.

description of the setup and the features of the experiment are presented in ref.[3].

A carbon target was installed in a vacuum pipe of the slowly extracted beam channel. The particles emitted at forward angles ($\vartheta <$ 0.4°) were bent by an M0 magnet to the setup axis. (The deflection angle was 150 mrad relative to the deuteron beam axis).

When measuring the momentum spectrum of the deuterons, the mean momentum of the particles directed to the setup axis was changed with a step of 0.02 p_d by appropriate changing of the M0 magnetic field. To ensure the constancy of the relative momentum acceptance of the setup, the M1 field was changed in proportion to the M0 field so that the particles, moving along the setup axis, hit the centre of the S_4 counter (200x350 mm^2). Values of the magnetic fields were measured with a 0.1% accuracy using Hall probes.

The primary beam intensity was varied between $5 \cdot 10^8 \div 2 \cdot 10^{10}$ particles /burst to ensure detector rates at a level of $(0.5 \div 1.0) \cdot 10^6$ particles/sec.

To measure the deuteron flux captured by the target, scintillation telescopes T1,T2 were used. The total deuteron beam intensity was monitored by a telescope T3. On-line monitoring of the extracted beam parameters was provided by information exchange between the setup computer and a computer, which controls the accelerator performance.

Data were taken under three different trigger conditions TR1,TR2, TR3. The main mode was $TR1 = S_1 \wedge S_2 \wedge S_3 \wedge S_4$. Using the information taken with trigger $TR2 = TR1 \wedge \check{C}_1 \wedge \check{C}_2$, the proton contamination of the secondary beam was determined. The threshold Cherenkov counters were tuned for the detection of protons with a momentum of $\gtrsim 5$ GeV/c. The $TR3 = K1 \wedge K2 \wedge K3 \wedge S_4 \wedge \bar{A}$ trigger was used to check detector efficiencies.

To take the spectrometer efficiency into account correctly under possible variations of the experimental situation, the triggers were switched under computer control with a period of 10 cycles of acoeleration.

Data processing was made by analogy to the procedure used when processing our data on d→p fragmentation (see ref.[4]). Events were accepted when

1) interaction point coordinates (measured with an accuracy of ±10mm in a plane perpendicular to the primary beam axis) were within target boundaries;
2) values of momentum and emission angle of the detected particle did not exceed acceptance boundaries.

These boundaries were fixed so that the corrections for geometrical efficiency near the boundaries did not exceed a value of 30%. Under these conditions the momentum acceptance interval was $p_o(1 \pm 0.06)$ where p_o is the momentum of a particle moving alongside the setup axis. The emission angles accepted by the setup were located in the region $|\theta_y| \leq 2$ mrad, $|\theta_x - \theta_o| \leq 2$ mrad. The θ_o value was momentum-dependent and varied between (-7;7) mrad for the above momentum region. The momentum resolution of the setup was $\sigma_p / p \simeq 0.4\%$.

The inclusive differential cross section of deuteron-carbon scattering was determined using information taken under TR1 conditions. In this region protons from d→p fragmentation were also detected with momenta being less than a maximum kinematically allowed momentum of 8.1 GeV/c. The invariant cross section for such protons had been measured by us [4] and was taken into account when obtaining the cross sections for the deuteron yield. The experimental background did not exceed 10% in the whole measurement region. The data normalization factor was determined in our paper [4] with an accuracy of 10%. Therefore the data were not corrected for multiple nuclear scattering in the target, which did not exceed 6%.

III. Results and discussion.

The obtained data are presented in Table 1 and fig.2.

Table 1

The invariant cross sections for inelastic deuteron-carbon scattering at deuteron momentum p_d =8.9 GeV/c

N	p/p_d	$\|t\|$ GeV^2/c^2	cross section, $\frac{mb \cdot GeV}{sr \cdot (GeV/c)^3}$	N	p/p_d	$\|t\|$ GeV^2/c^2	cross section, $\frac{mb \cdot GeV}{sr \cdot (GeV/c)^3}$
1	0.7050	0.408	19.7±6.4	14	0.7875	0.191	14.9±2.6
2	0.7150	0.376	8.6±6.1	15	0.7925	0.181	18.1±2.8
3	0.7250	0.345	3.4±4.2	16	0.7975	0.171	17.9±2.5
4	0.7350	0.316	8.4±4.3	17	0.8025	0.162	18.1±2.6
5	0.7425	0.296	16.4±5.2	18	0.8075	0.153	22.8±2.9
6	0.7475	0.283	17.4±4.2	19	0.8125	0.144	22.7±2.9
7	0.7525	0.270	14.2±3.5	20	0.8175	0.136	24.5±2.6
8	0.7575	0.258	15.2±3.0	21	0.8225	0.128	31.5±3.2
9	0.7625	0.246	14.0±2.8	22	0.8275	0.120	43.5±4.3
10	0.7675	0.234	13.8±2.8	23	0.8325	0.112	37.2±4.0
11	0.7725	0.223	14.5±2.9	24	0.8375	0.105	33.2±3.8
12	0.7775	0.212	13.7±2.4	25	0.8425	0.098	39.0±4.0
13	0.7825	0.201	18.1±2.3				

1	2	3	4	5	6	7	8
26	0.8475	0.092	66.5±6.1	38	0.9075	0.032	242±14
27	0.8525	0.085	64.7±6.0	39	0.9125	0.028	256±16
28	0.8575	0.079	71.3±6.1	40	0.9175	0.025	259±16
29	0.8625	0.073	89.2±7.4	41	0.9225	0.022	270±17
30	0.8675	0.068	127±10	42	0.9275	0.019	388±32
31	0.8725	0.062	117±10	43	0.9325	0.016	441±33
32	0.8775	0.057	129± 8	44	0.9375	0.014	544±37
33	0.8825	0.052	145± 9	45	0.9425	0.012	417±34
34	0.8875	0.048	151±10	46	0.9475	0.010	456±42
35	0.8925	0.043	183±13	47	0.9525	0.008	709±68
36	0.8975	0.039	219±13	48	0.9575	0.006	734±69
37	0.9025	0.035	192±12	49	0.9625	0.005	766±71

The quoted uncertainties are statistical in nature. The shape of the spectrum for p/p_d 0.96 is also presented in fig.2. The data, obtained in this region, are excluded from Table 1 and will not be discussed below because in this region the spectrum shape represents, in fact, the momentum resolution function of the apparatus.

In fig.2 one can see a fast decrease of the deuteron yield with growing the loss of the longitudinal momentum in an interval of $0.7 \leq p/p_d \leq 0.96$, after which the rate of decreasing the yield falls quickly. It is possible that there are some evidences for an irregular behaviour of the measured cross sections for $p/p_d \sim 0.83$ and $p/p_d \sim 0.94$.

The obtained data can be compared with results of other experiments. In the paper of Papp et al.[5] data are presented on the deuteron momentum spectrum for the reaction $d/C \to dX$ measured at momenta of 3.5 GeV/c and 5.8 GeV/c. The observation angle was 43.6 mrad in this experiment. From fig.3 one can see that the results of both experiments are in accordance.

The experiment of L.S.Azhgirey et al.[6] has been performed at deuteron momenta of 4.3 GeV/c, 6.3 GeV/c and 8.9 GeV/c with an observation angle of 103 mrad. The minimal t-value was about 0.2 GeV^2/c^2 for the 4.3 GeV/c deuteron beam. The authors of ref.[6] have presented the differential cross sections integrated over detected deuteron momenta in intervals of (3.44÷4.05)GeV/c for the 4.3 GeV/c beam, (5.0÷5.9)GeV/c and (2.6÷3.6)GeV/c for the 6.3 GeV/c beam and (6.62÷8.21)GeV/c for the 8.9 GeV/c beam. From the data we estimated the invariant cross sections:

$$\frac{E}{p^2}\frac{d^2\sigma}{dpd\Omega} \approx \frac{\bar{E}}{\bar{p}^2}\frac{1}{\Delta}\frac{d\sigma}{d\Omega},$$

where $\bar{p}$ is the mean momentum of the detected deuterons for the momentum intervals quoted above, Δ is the width of these intervals, $\bar{E} = (\bar{p}^2+M_d^2)^{1/2}$, and M_d is the deuteron mass. The estimated invariant cross sections and t-values, corresponding to the above momentum intervals, are presented in Table 2 and shown in part in fig.2.

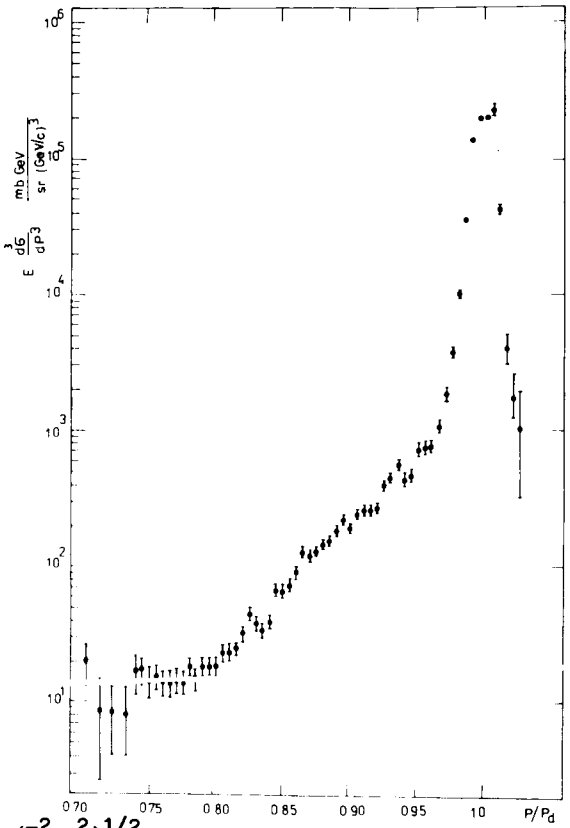

Fig.2. The invariant cross section of inelastic deuteron-carbon interactions depending on the part (p/p_d) of the initial momentum p_d = =8.9 GeV/c, carried by the detected deuteron emitted in the forward direction.

Table 2.

beam momentum (ref.[6]) (GeV/c)	interval of detected deuteron momentum (GeV/c)	mean value of $\lvert t \rvert$ $(GeV/c)^2$	invariant cross section[6], $\frac{mb \cdot GeV}{sr \cdot (GeV/c)^3}$
4.3	3.44-4.05	0.226	10.5±1
6.3	5.0-5.9	0.431	2.1±0.5
	2.6-3.6	1.74	3.9±0.9
8.9	6.62-8.21	0.81	1.4±0.2

The uncertainties, quoted in Table 2, include the values of systematical and statistical errors given in ref.[6].

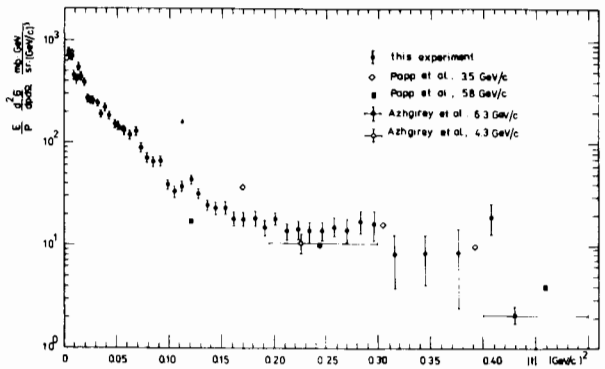

Fig.3. The invariant cross section of inelastic deuteron--carbon scattering, when the detected deuteron is emitted in the forward direction, depending on the 4-momentum transfer squared, t.

This comparison shows that the results of our experiment are in accordance with the data of refs./5,6/. Taking together the data previously existed /5,6/ and obtained by us, one can conclude that in the region of $|t|$ from 0.2 GeV^2/c^2 up to $|t| \approx 2.5$ GeV^2/c^2 the cross section falls off considerably more slowly, when growing $|t|$, than in the region of $|t| \lesssim 0.2$ GeV^2/c^2.

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References

1. Baldin A.M., Progr.Part. & Nucl.Phys., 1980, 4, p.95
   Bergström L., Fredriksson S., Rev.Mod.Phys., 1980, 52, p.672.
2. Meshcheryakov M.G. Proc.VI Intern.Seminar on High Energy Physics Problems, JINR, D1, 2-81-728, Dubna, 1981, p.260;

Dorkin S.M. et al., JINR, P2-82-81, Dubna, 1982.
3. Ableev V.G. et al., JINR, 13-81-782, Dubna, 1981.
4. Ableev V.G. et al., JINR, E1-82-377, Dubna, 1982.
   Ableev V.G. et al., JINR, P1-82-276, Dubna, 1982.
5. Papp J., LBL-3633, Berkeley, 1975.
6. Azhgirey L.S. et al., YaF., 1978, 27, p.1027;
   JINR, E1-12296, Dubna, 1979.

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Неупругое рассеяние дейтронов на углероде при импульсе 8,9 ГэВ/с

С помощью магнитного спектрометра "Альфа" подробно измерен импульсный спектр дейтронов, неупруго рассеянных на углеродной мишени в интервал углов $0 \leq \theta < 0{,}4°$ и потерявших в результате рассеяния до 30% от начального импульса 8,9 ГэВ/с.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1982

Ableev V.G. et al.

E1-82-517

Inelastic Scattering of 8.9 GeV/c Deuterons on Carbon

Using the magnetic spectrometer "Alpha", detailed measurements of the momentum spectrum of the deuterons, scattered inelastically on a carbon target in an angular interval of $0 \leq \theta < 0.4°$, have been performed. After the scattering the deuterons lost up to 30% of an initial momentum of 8.9 GeV/c.

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

Preprint of the Joint Institute for Nuclear Research. Dubna 1982