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INVESTIGATION OF THE CHARGE-EXCHANGE REACTION $(^3He, t)$ AT 4.37, 6.78, AND 10.78 GeV/c WITH Δ-ISOBAR EXCITATION IN CARBON

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1. The invariant cross sections of the $(^3He,t)$ reaction on C and CH_2 targets at triton emission angles of $\theta \lesssim 0.4°$ were measured using the ALPHA-spectrometer /1/. The same geometry ("A") was used as in our investigations of (d,p) fragmentation /2/.

In this geometry the $(^3He,d)$ fragmentation cross sections were also measured using the same targets. At 10.78 GeV/c the absolute measurements of the $(^3He,d)$ cross sections were made in the region of $P_d \sim 2/3\, P_{^3He}$ using another geometry /3/ ("B"). In this region of fragment momentum the stripping cross section is practically independent of incident energy /4/. This allowed us to normalize our $(^3He,t)$ data at all projectile energies used. In the same geometry ("B") we also made the absolute measurements of the $(^3He,t)$ cross sections at 6.78 GeV/c. Preliminary results of these measurements are presented elsewhere /5/. The comparison of both sets of data (obtained in geometries "A" and "B") at 6.78 GeV/c confirms our estimate of normalization uncertainty ($\lesssim$10%) of the data in geometry "A". The statistical uncertainty of the $(^3He,t)$ data does not exceed 5%. The background contribution is no larger than 7% and independent of triton momentum.

2. The invariant $(^3He,t)$ differential cross sections obtained on proton and ^{12}C are presented in figs.1 and 2 versus the energy $Q = T_{^3He} - T_t$ (T is kinetic energy) transferred to the target nucleus. The Q resolution was: σ_Q = 20, 30 and 70 MeV at incident momenta of 4.37, 6.78, and 10.78 GeV/c, respectively.

A single peak is seen in the $p(^3He,t)$ reaction cross section (fig.1). The position and width of the peak are close to the expected ones for $p(^3He,t)\Delta^{++}$ reaction. The peak shape and location are distorted by the ^3He formfactor. This distortion vanishes with increasing incident momentum due to decreasing (at fixed Q) longitudinal momentum transfer $\Delta P_{\parallel}(Q)$ in the ^3He rest frame. The peak maxima are observed at $Q_0^{(P)} = 298 \pm 2, 307 \pm 1$, and 325 ± 1 MeV for incident momenta of 4.37, 6.78, and 10.78 GeV/c, respectively.

There are two peaks in the $^{12}C(^3He,t)$ cross sections (fig.2). The first one is located at small Q and corresponds to spin-isospin excitations of nuclear levels in the residual nucleus. The peak height decreases with increasing projectile energy, but this decrease can be only in part accounted for increasing σ_Q.

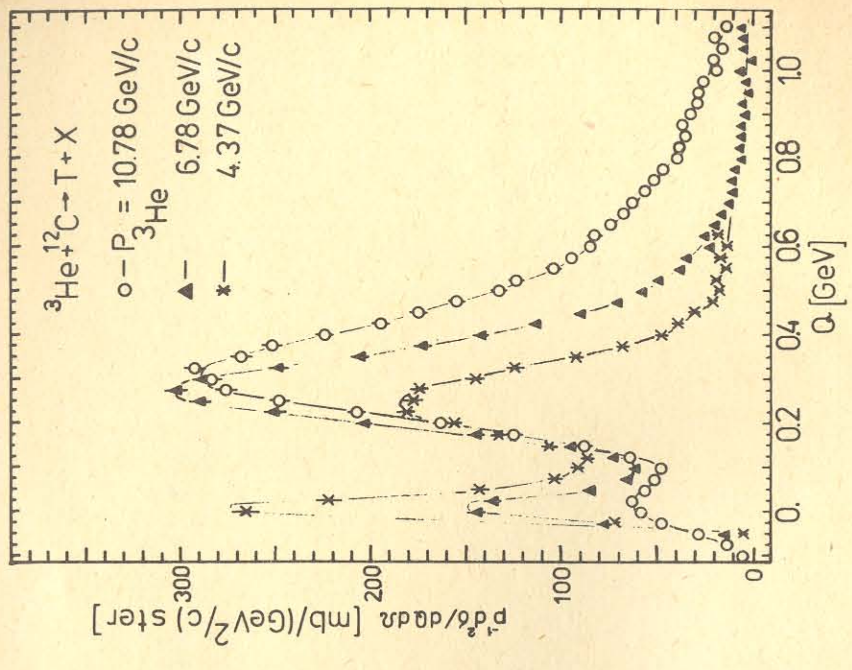

Fig.2. The (^{3}He,t) cross sections on carbon. The notations are the same as in Fig.1.

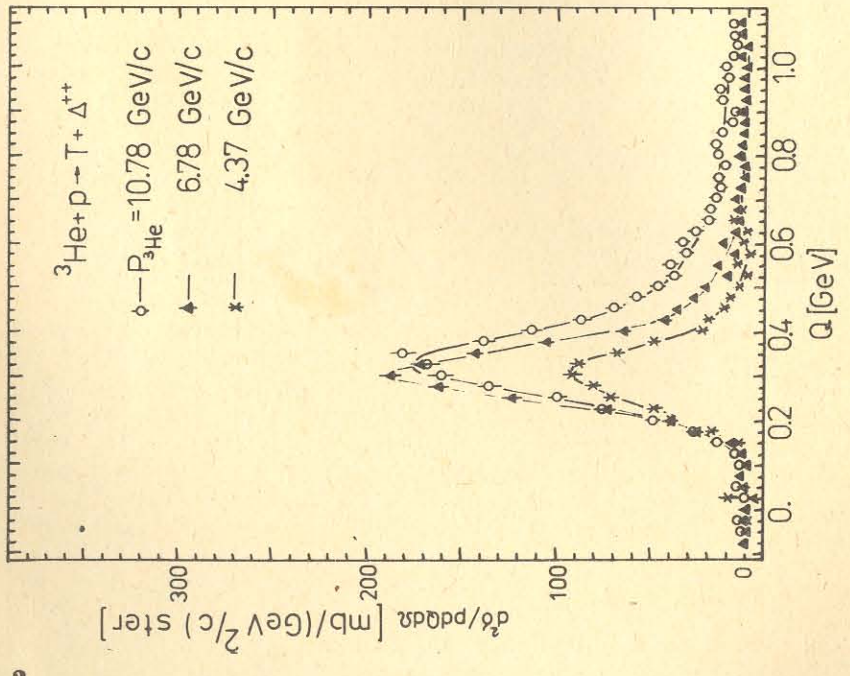

Fig.1. The (^{3}He,t) cross sections on protons. The curves are drawn to guide the eye.

The second peak is located in the same Q region as the peak in the P(^{3}He,t) reaction cross section, so further on we shall refer to it as to the Δ-peak.

At 4.37 and 6.78 GeV/c the location, height and width of the Δ-peak may be in principle distorted by the contribution from a tail of the first peak. But a crude estimation of a possible shift in the peak location (Q_0) shows that this shift is negligible (≲10 MeV) even at 4.37 GeV/c. Therefore we neglected this shift when estimating $Q_0^{(C)}$. The $Q_0^{(C)}$ values obtained are $Q_0^{(C)} = 245 \pm 2,\ 275 \pm 1$, and 315 ± 1 MeV.

3. From the comparison of the data it follows that:

(i) The contribution of the mechanism which determines the Δ-peak dominates the (^{3}He,t) cross section for the reaction on nucleus at 6.78 and 10.78 GeV/c (see fig.2).

(ii) The ratio (R) of the charge-exchange cross section

$$\frac{d\sigma}{d\Omega}(0) = \int_{Q \geq 75\,MeV} \frac{d^2\sigma}{dp\,d\Omega}\,dp$$

for carbon and proton increases with increasing incident momentum varying from ~0.5 (Saclay data [6] at 3.9 GeV/c) to ~1.6 at 4.37 GeV/c (the contribution of the tail from the nuclear excitation peak being subtracted) and ≃2.3 at 6.78 and 10.78 GeV/c.

(iii) As is seen from fig.3 and the Q_0 values presented above, there is a shift between the Δ-peak positions in the reaction on C and P at fixed incident energies. This shift can be understood from kinematics if a group of target-constituent nucleons is assumed to participate in the "elementary act" of Δ production because $\Delta P_{\parallel}(Q)$ at fixed Q and incident energy decreases with increasing target mass.

4. To make sure that it is impossible to account for these facts (see also paper [5]) assuming that the Δ-isobar is produced on a single moving target-constituent nucleon, we have calculated the charge-exchange cross sections of the (^{3}He,t) reaction at 6.78 GeV/c by the Glauber-Sitenko model taking longitudinal momentum transfer into account. The experimental values of the parameters of the $NN \to N\Delta$ reaction and the ^{3}He form factor were used as an input. The oscillator wave function of ^{12}C and the shell model wave function were also used. It was found that the form of the wave function does not change the results appreciably. The calculated cross section for the reaction on proton is in accordance with the experimental data, but the one for the reaction on carbon is in sharp qualitative contradiction with the data: the ratio R is about 0.8 instead of 2.3; $Q_0^{(C)} > Q_0^{(P)}$, while in the experiment $Q_0^{(C)} < Q_0^{(P)}$. It was found that any variation of the input parameters of the model,

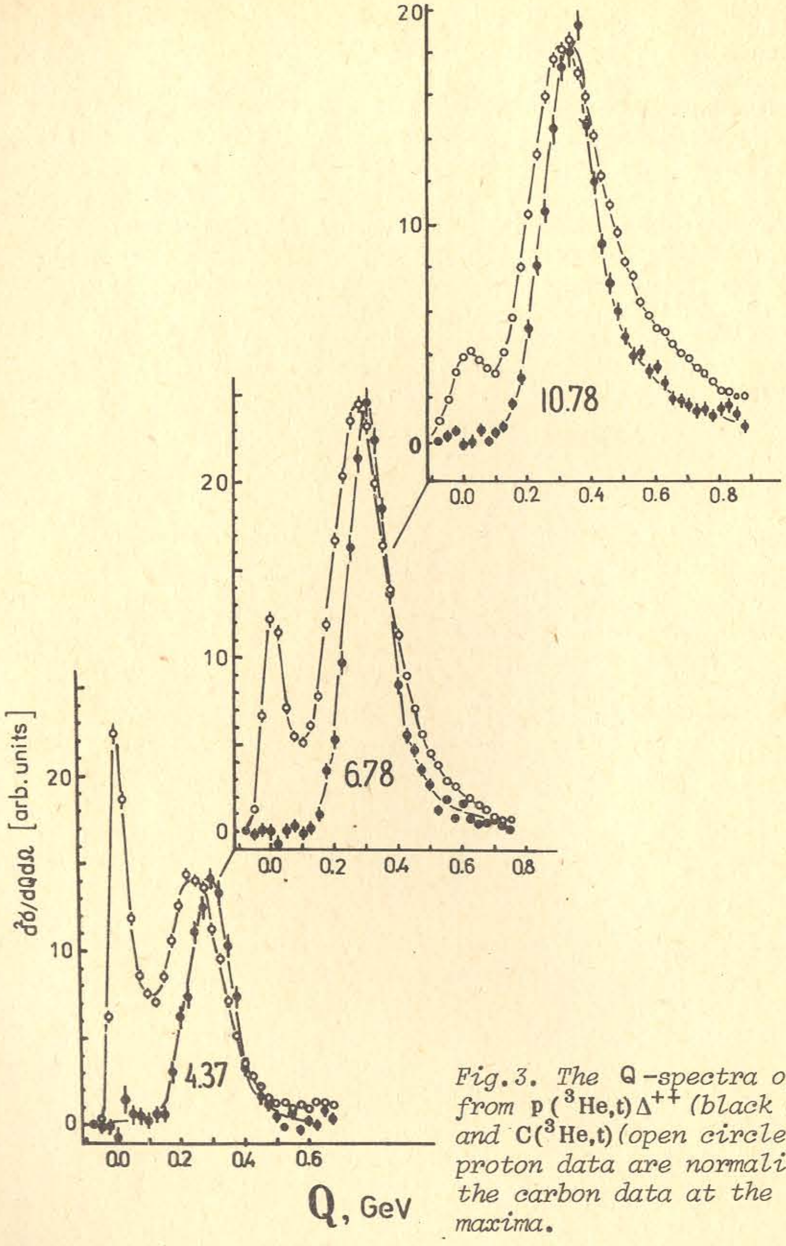

Fig.3. The Q-spectra of tritons from $p(^3He,t)\Delta^{++}$ *(black circles) and* $C(^3He,t)$ *(open circles). The proton data are normalized to the carbon data at the* Δ*-peak maxima.*

within their uncertainties, as well as taking final state interaction effects into account, do not provide even a qualitative agreement with the data.

5. So, the comparison of the data on absolute ($^3He,t$) cross sections on proton and ^{12}C, as well as the Glauber calculation results, show that in the charge-exchange reaction with Δ production in nuclei at high energies such mechanisms of the collective type are essential, which cannot be reduced to Δ-production on a single target-constituent nucleon.

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Аблеев В.Г. и др. E1-84-438
Возбуждение Δ-изобар в ядрах углерода
в реакции перезарядки (^{3}He,t) при 4,37; 6,78 и 10,78 ГэВ/с

Впервые при высоких энергиях измерены сечения реакции (^{3}He,t) на протоне и ^{12}C с рождением Δ-изобар. Статистическая погрешность $\lesssim 5\%$, погрешность нормировки $\lesssim 10\%$. Показано, что в этой реакции с рождением изобары в ядре существенны механизмы, не сводящиеся к рождению ее на одном из нуклонов ядра.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1984

Ableev V.G. et al. E1-84-438
Investigation of the Charge-Exchange Reaction (^{3}He,t)
at 4.37, 6.78, and 10.78 GeV/c with Δ-Isobar
Excitation in Carbon

The cross sections of p(^{3}He,t)and C(^{3}He,t)reactions with Δ-isobar excitation in target nuclei have been first measured at high projectile energies. The statistical uncertainty of the data does not exceed 5%, the normalization one is less than 10%. These data lead to the conclusion of a significant role of collective type mechanisms, which cannot be reduced to Δ-production on a single target-constituent nucleon when complex nuclei are used as a target.

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

Preprint of the Joint Institute for Nuclear Research. Dubna 1984