NUCLEAR MATTER FLUCTUATIONS

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The processes of multinucleon interaction are investigated in π-C reactions at 5 GeV/c. The obtained data indicate that the process π-quasi-elastic collision with the massive coherent nuclear matter fluctuation inside the carbon nucleus play a considerable role in multinucleon interactions.

1. Introduction

Processes of multinucleon hadron-nucleuse scattering hA at high energies, leading to emission of relatively fast (cumulative) baryons from nuclei into the backward hemisphere (B) are objects of intensive experimental and theoretical investigation for many years [1,2]. The attention to reaction of emission of "backward baryons B" is attacked first of all by an opportunity of obtaining essentially new information on the properties of intranuclear nucleons, their associations into close groups [3,4], and the interaction of the primary or cascade hadron with clusters of the d, alfa, ... type [5-8] or with considerably closer objects, such as quark bags[9,10] in nuclei.

To find a relative contribution of the above-mentioned mechanisms to the process of cumulative baryon production, one usually studies multi-particle correlations within certain limited regions of the phase space for secondary particles.

The investigations in this field [11] allowed us to reveal an opening angle correlation of two protons, angle between them being close to 180° (one of the protons was emitted into the back hemisphere in the lab. frame).Study of the this effect showed [5] that it can be partially due to absorption of slow cascade pions by an associated pair of nuclear nucleons, i.e.,due to the process $\pi + (NN) \ldots P\downarrow + N$ Then this point of view was confirmed by other experiments [12,13].

2. Experimental results

In 1957 D.I.Blokhintsev [3] proposed a hypothesis on the existence of nuclear matter coherent fluctuations to explain the massive fragment knock-out of nuclei [2]. Later, this hypothesis was used by A.M.Baldin [1] to explain the cumulative effect. It should be stressed, however, that there is a principle difference between the fluctuations of nuclear matter and clusters discussed in nuclear physics. Indeed, the typical momentum transfer in the cumulative process $t=-2ME$, where E is the total energy of the particle emitted, M is the mass-clot of nuclear matter, reaches a few GeV/c. This momentum transfer corresponds to the localization of this process in the range of about 0.1f i.e., ten times smaller than that of the usual nuclear cluster. Under these conditions the nuclear matter fluctuation could be treated as an elementary consisting of the larger than usual number of quarks. Hadron collisions with such a particle should be rather similar to inclusive hadron processes with a large transverse momentum.

Such quark-parton modification of the nuclear fluctuation hypothesis allowed one of the authors [4] to propose the qualitative explanation of some cumulative particle production regularities on nuclei.

The essential prediction of such a model is the presence of the angular correlations between two particles emitted in the same direction ($\theta = 0°$) and especially in the opposite one ($\theta = 180°$). This is a result of the central collision and of the following collaps of two partons.

Correlations of this type have been observed in hadron processes with the large transverse momenta $P_\perp$ [14].

The purpose of the present experiment is to search for and study the correlations at the emission angles of charged particles (P, $\pi^\pm$-mesons) in π^--carbon interactions at 5 GeV/c.

As many as 15000 π^-C interactions have been found in scanning 200000 pictures obtained with the one-meter propane bubble chamber. These events were measured and analysed.

The correlations at the lab. system emission angles for different particle pairs (protons, P, and charged pions) have been investigated. One of the taken particles was always emitted in the backward hemisphere (lab. system).

There were analysed the experimental distributions of $\cos\theta$, here θ is an opening angle for the proton-proton pairs and for the proton charged particle ones in the corresponding intervals of the "trigger" particle (proton) momenta:

a) $p\downarrow(0,18-0,6)-p(0,18-0,6)$ GeV/c,
b) $p\downarrow(0,18-0,3)-p(0,18-0,6)$ GeV/c,
c) $p\downarrow(0,3-0,6)-p(0,18-0,6)$ GeV/c,
d) $p\downarrow(0,18-0.6)$ - all charge pions and protons,
e) $p\downarrow(0.18-0.3)$ - all charge pions and protons,
f) $p\downarrow(0.3-0.6)$ - all charge pions and protons.

The similar analyses have been carried out also for these cases when π^+ and π^- mesons were selected as "trigger" particles. The experimental data were been compared with background data, which were been obtained on the basis of the single-particle polar angle cosine distributions (a "trigger" particle-1 and a particle in matter-2) in the following way:

$$V_B(x) = \int W_1(x_1) W_2(x_2)\, \delta(\hat{x} - x)\, dx_1 d\varphi_1 dx_2 d\varphi_2$$

where

$\hat{x} = \bar{n}_1\bar{n}_2 = x_1x_2 \pm \sqrt{(1-x_1^2)(1-x_2^2)}\cos(\varphi_1 - \varphi_2)$; $\bar{n}_1\bar{n}_2$ is a unit vector in the emission direction of the particle 1(2) in lab. system, x_i, φ_i are the polar angle cosine and the azimuthal angle of the i-th particle emission (i=1,2), W_1 and W_2 are the single-particle inclusive distribution of the polar angle emission cosine (in the corresponding interval of particle momenta), x is the cosine of the opening angle between two particles (lab. system).

For various "trigger"-particles (p, π^+, π^-) the ratio of the experimental distribution to the background one

$$C(x) = V_{exp}(x) / V_B(x)$$

has a maximum at $x = -1$ and amounts to about 2. Besides, as a rule $C(-1)$ is larger for the faster "trigger" particles (the back protons within the momentum interval of 0,3 - 0,6 GeV/c) than for the lower ones (0,18-0,3 GeV/c), i.e., a noticeable correlation of particles emitted in opposite directions is observed.

The similar result for the angle emission distribution is observed when study the large transverse momentum interactions (azimuthal correlations)[14]. In the case of large $P_\perp$~2-5 GeV/c our results on $C(x)$ are in agreement with the above quoted experiment [14].

3. Conclusions

1. The obtained results allow us to treat the correlation observed in our experiment to be due to the incoming π-quasi-elastic collision with the massive coherent nuclear matter fluctuation ("flucton") inside the carbon nucleus.
2. The correlation similarity in the cumulative and in the large $P_\perp$ particle production processes could be treated in favour of these two production mechanisms similarity.

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NÜVƏ MADDƏSİNİN FLUKTUASİYALARI

İmpuls enerjisi 5 HeV/c olan π mezonların karbon nüvə ilə reaksiyalarda olan çoxnuklonlu qarşılıglı tə'sirinin tətbigi aparılıb. Alınan nəticələr göstərir ki, karbon nüvənin daxilində π mezonun ağır hogerent fluktuasiyasi ilə kvazielastik tokkuşma proseslərin vahid rolu var.

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ФЛУКТУАЦИИ ЯДЕРНОЙ МАТЕРИИ

Проведены исследования многонуклонных взаимодействий в π-C реакциях при 5 ГэВ/с. Полученные данные указывают на то, что процессы квазиупругих столкновений π мезона с массивной когерентной флуктуацией ядерной материи внутри ядра углерода играют существенную роль в многонуклонных взаимодействиях.

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