CLUSTER-FLUCTONS REVELATION IN NUCLEAR INTERACTIONS AT 4.2 (GEV/C)/N

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The question about the correlations between nucleons in the nuclei and the conservation of their own individualities has always been, for many researchers, an interesting puzzle. As early as 1949 K.Brueckner et.al. [1] brought a report about space nucleon correlations in nuclei. In 1950 J.Hadley et.al. [2] studied forward emission of high momentum deuterons in p+nucleus interactions. M.G. Mescheriakov et.al. [3], Ajgirei et.al. [3] discovered the effect of deuterons knocking out from Li, Be, C... In 1956 Bete mentioned the short-range interactions between the pairs of nucleons in nuclei. Further, in 1957 D.I. Blokhintsev proposed [5] a very productive idea, that high momentum components of particles produced are connected, with some clusters, consisting of nucleons, also called fluctons. In the seventies many papers were published [6] on nuclear fragmentation, pions production in nuclear interactions, etc. Particularly, it was shown, that pions spectra couldn't be reproduced by any model, in which the pions generation is attributed to collisions between individual nucleons inside the nucleus only.

Cumulative particles, i.e. particles with momentum greater, than that allowed by nucleon-nucleon kinematics, began to be an object of intensive studies after the publications of G.A. Leksin et.al.[7], and A.M. Baldin [8]. Strictly speaking, all products of the nuclear-nuclei interactions are cumulative ones, just because of the existence of Fermi momentum. But in this case the particles are meant that had obtained an unusually great moment, and the total situation has became quite different. In this field a lot of experimental data were obtained by Stavinskiy V.S. et. al. [9]. Cumulative processes with high momentum transfer enjoy nowadays a special interest. A review of the first experimental cumulative data and the analysis of these data from the point of view of the new hypotheses were made by V.K. Lukyanov and A.I. Titov [10]. It was shown, that the hypothesis about the nuclear density fluctuations and quark-parton interaction mechanism existence can be the base of the large momentum transfer and etc.

That study was undertaken in order to pick out and to analyze the groups of events, in which two, three or more nucleons had taken part at the interactions. By comparing such events with collisions of elementary particles, it is possible to study the interactions of groups of nucleons as a whole object: flucton. The quazy-nucleons and fluctons that may compose the nucleus, we shall sign as 'F'. One nucleon flucton is N_F, two nucleon – is d_F. The type of the nucleus is signed by upper index.

In this situation the experimental data of protons, deuterons and carbons interactions with protons and carbons from propane (C_3H_8), obtained in propane bubble chamber at 4.2 (GeV/c)/N [11] were used. The interactions p + C_3H_8, d + C_3H_8, C + C_3H_8 were divided on p+p and p+C, on d + C and d + p; on C+C and C+p-collisions correspondently by the way, proposed in [12].

The calculation and analyses of some total values for every event, based on charged particles, registered inside the chamber, represent an important part of this study. These values are as follows:

ΣP^i_y –total longitudinal momenta of all charged particles. As long as all particles run along the y-axis, the registered value should be $\Sigma P^i_y = nP_0$, where P_0 is the momentum of the beam and n=1, 2, 3, . . depending on the number of the initial interaction nucleons. There is obviously, that for p+C, p+p–collisions: n=1, but for d+C, d+p, when both nucleons take part in the interaction: n=2. In case, that one initial nucleon takes part at the interaction (n=1), one maximum may be seen in the ΣP^i_y-spectrum. Observation of several maxima corresponds to the superimposition of a number of spectra, having the next maximum values of summary momentum: ≈4.2, ≈8.4, ≈12.8 GeV/c, ... It accords to the fact, that 1, 2, 3, ... nucleons from the flying nuclei interact with the target.

The next value is the interaction energy $M_{tot,0}^2=(\Sigma E^{1,2}_0)^2 - (\Sigma P^{1,2}_0)^2$, where $E^{1,2}_0$ and $P^{1,2}_0$ – are the energy and momenta of initial particles. On the other hand the value of interaction energy may be calculated, using the reaction products: $M_{tot}^2=(\Sigma E_i)^2 - (\Sigma P_i)^2$, where E_i, P_i-are the energies and momenta of all particles produced. If all products are registered, $M_{tot,0}^2 = M_{tot}^2$.

Let us consider C+C, C+p, d+C – interactions, (or more exactly d_F^C + N_F^C, d_F^C + p and d + N_F^C), for which $\Sigma P^i_y \cong 8.4$GeV/c. There are two nucleons from the flying carbon which have taken part at the interaction: n=2. If both nucleons interact with two target nucleons independently, or – with one "quazy-deuteron" (that is $n_{part}=4$, where n_{part} is the number of interacted particles), than such events will come to the region of 39÷40 $(GeV)^2$ in M_{tot}^2 spectra. However, it does not seem to be the case: most of the events, coming from the $\Sigma P^i_y \approx 8.4$ GeV/c- interval, settled down near $M_{tot}^2 \approx 20$ $(GeV)^2$, i.e. $n_{part}=3$.

The M_{tot}^2-distributions for C+C, C+p-, and d+C, d+p –collisions for two ΣP^i_y –stripes: $\Sigma P^i_y \approx 4.2$GeV/c, n=1, and ≈8.4GeV/c, n=2 are shown on fig. 1 and fig. 2, correspondently. As seen on figs. 1 and 2 again the events are grouped near the two M_{tot}^2 values: $M_{tot}^2 \cong 9.8$ and 20 $(GeV/c)^2$. So, the events with n=1 and $n_{part}=2$ are in accordance with nucleon-nucleon kinematics, obviously are included in the first group. The second group of events corresponds to the interactions of two flying protons with one target's nucleon successively via secondary collisions or simultaneously.

It was shown[14], that the events with three nucleons interaction differ from two nucleons interactions strongly, both in one particle longitudinal momentum spectra and in multiplicities of generated particles.

For example, let us consider the P^i_y-spectra of all charged particles for the reactions of quazy-nucleon or free nucleon with two nucleons from the carbon - target: $N_F^C + d_F^C$, $N_F^d + d_F^C$, $p + d_F^C$. Further, let us suppose, that the coming fly nucleon interacts with the two target nucleons "successively": one flying nucleon interacts with one target nucleon, followed by another target nucleon interacting with the product from the first interaction. In that case on the basic of mean momentum particles analysis [14], it is necessary to suppose that more than 85% of particles, produced in the first collision, interact with the other nucleon. But it is not possible, because it leads to strong increasing of charged particles multiplicity (see table. 1). For example, as it is seen from the table 1, the ratio of particle multiplicity observed of two nucleon ("flucton") – nucleon interactions to multiplicity of nucleon-nucleon collisions turn out:

$n_{ch}(p+d_F^C)/n_{ch}(p+p)=1.26\pm0.10$, and –

$n_{ch}(d_F^C+ p)/n_{ch}(d(\text{one nucleon})+ p)=1.25\pm0.06$.

So, from the charged particle multiplicity analysis the next conclusion is follows: $(20\div30)\%$ of all produced particles interact in the nuclei again.

So, the secondary interactions contributions, calculated on the basics of mean momenta of one particle spectra and from mean values of charged particles multiplicities are not agreed one with another. It is quite possible that secondary interactions machanism do not work here at all.

The cumulative particles, well known from some experiments, were observed in these reactions too.

Let us mark, that the appearance of protons with moment $P^p_y>4.2$ GeV/c in $d_F^C + N_F^C$ – reaction, show up the maximum violation of nucleon- nucleon collision kinematics. The number of such protons compiles $(12.5\pm1.5)\%$ from all produced protons. Cumulative particles generations moving backward in the same reaction are due to secondary interactions and to Fermi movement only. Therefore, the number of such particles is very small: less than 1.0% of all protons fly backward. It was proved in [9] that abundant production of cumulative particles, moving in beam direction or backward, especially – production of protons flying backward in reaction $N_F^C+d_F^C$, for example, can be explained neither by Fermi-momentum nor by secondary interactions in the nuclei. As seen from distribution of longitudinal proton momenta for reaction $N_F^C+d_F^C$, $(n=1, n_{part}=3)$ more than $(14\pm2)\%$ of all protons move in direction opposed to the nucleons beam.

So, longitudinal momenta spectra and multiplicities of charge particle analysis and distinction of cumulative particles production in d_F^C+p and d_F^C+p-reactions suggest reasonable assumption that two nucleons are combined as one flucton even before interaction. Then high momentum P^+_t and P^+_y appearance become more probable when a flucton with momentum 8.4 GeV/c instead of a nucleon with momentum 4.2 GeV/c, interacts with the target. So, for example abundant production of cumulative protons, coming fly backward may be explained easily if it is supposed that one nucleon interacts with two nucleons, i.e. with a flucton.

Let us note, that the values of mean transverse momenta of positively charged particles $<P^+_t>$ increase for nuclear-nuclei interactions compared with nucleon-nucleon ones. And they become even greater for the reactions with fluctons participations (see table 2).

We are realizing, that the conclusion obtained must be tested in future on a high statistics basis. Also all particles registrations are needed for the better channels separation.

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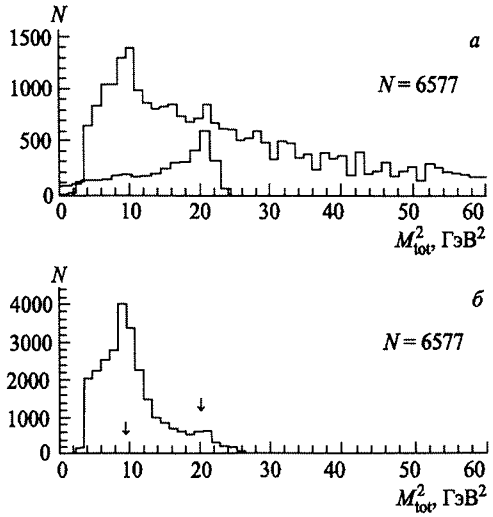

Fig.1A, B. Distributions of total energy M_{tot}^2 $(GeV)^2$ for (À) C+C and (B) C+p-collisions for the two groups of events with summary longitudinal particle momentum $\Sigma P^i_y \approx 4.2$ GeV/c and ≈ 8.4 GeV/c.The inside histogram[14] is the particles spectrum for n=2 nucleon interaction with the nucleon target. It is not normalized

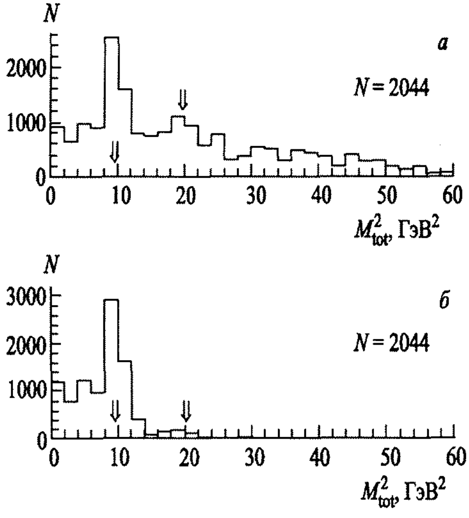

Fig.2A, B. Distributions of total particle energy M_{tot}^2 $(GeV)^2$ for (À) d+C- and (B) d+p-collisions for the two groups of events with summary longitudinal particle momentum $\Sigma P^i_y) \approx 4.2$ GeV/c and ≈ 8.4 GeV/c.

Table 1. Mean values of charged particles multiplicity

Target Initial coming fly particle	d_F^C n_{ch}	N_F^C n_{ch}	p n_{ch}
p [15]	4.05±0.27	2.97±0.12	2.86±0.22 2.37÷2.60
N_F^C	3.73±0.79	2.94±0.46	2.73±0.25
d_F^C	3.30±0.20	3.82±0.76	3.37±0.58
d(both nucleons)	-	3.05±0.14	2.95±0.18
d(one nucleon)		2.78±0.20	2.70±0.21

Table 2

Reactions	$< P^{i,+}_t >$ GeV/c	$< P^{i,+}_y >$, GeV/c
p+p	0.464±0.009	1.508±0.030
N_F^C+p	0.496±0.014	1.819±0.058
p+ d_F^C	0.474±0.025	1.189±0.075
N_F^C+ d_F^C	0.519±0.029	1.176±0.072
d_F^C+p	0.550±0.024	2.479±0.118
d(both nucleons)+ N_F^C	0.563±0.070	2.265±0.283
d(both nucleons)+ p d+p	0.532±0.093 {0.458±0.009}	2.350±0.616 {1.525±0.033}

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