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THE DEEP INELASTIC SCATTERING OF LEPTONS ON THE CARBON IN THE FLUCTON MODEL

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The deep inelastic muon scattering on carbon nuclei $\mu^{12}C \to \mu X$ in the cumulative region of the Bjorken variable $x > 1$ discovered by the BCDMS collaboration /1/ and the similarity of the cumulative muon and hadron spectra make it possible to neglect some models of the cumulative effect.

There are, for example, "hydrodynamical" - type models (fireball, etc.) and rescattering models requiring the strong interaction between the projectile particle and nucleons. Also, the predictions of the Fermi-motion model do not agree with the experimental data /1/.

On the other hand, the non-zero nucleus structure function $F_2^A(x)$ at $x > 1$ seems to be natural in the models, which imply the existence of some few-nucleon structures like Blokhintsev fluctons /2/ or of few-nucleon momentum correlation /3/ (FMC). We think that all such models should be "normalized" to the experimental data to specify their parameters and to make clear their difference in other phenomena. Such a normalization has been performed in the FMC /3/ and flucton model with the quark counting rules for the structure functions /4/. But in the latter case it has required a half decrease in the quark powers. We believe it to be unsatisfactory.

We suppose that the minimal excitation of the quark degrees of freedom in the multiquark fluctons takes place. Only one-quark colour-singlet triplet is excited. The other triplets turn into nucleons (and nuclear fragments) without any internal excitation and so can be viewed as point-like objects.

Thus, our main hypotheses are /2/:

(1) In the nucleus some quasiresonance compositions of nucleons with a definite energy and width, named fluctons, appear and disappear all the time.

(2) The mechanism of the cumulative muon production is the hard scattering of muons on nuclear fluctons (in contrast with the cumulative hadron production where, we think, this mechanism is not so clear).

The structure function $F_2^A(x)$ can be represented as follows (Fig.1):

$$F_2^A(x) = \sum_{k=1}^{A} P(k, A) \cdot \sum_q e_q^2 \cdot x \cdot q_k(x) \qquad (1)$$

(For simplicity we have neglected the Fermi-motion of fluctons).

Consider some components of this expression:

(A) $P(k, A)$ is an average number of the k -nucleon fluctons in the nucleus A. Suppose that the fluctons size (coherence region) is near the nucleon size, $r_c \sim 0{,}7 \div 0{,}8$ fm, $V_c = 4/3 \cdot \pi \cdot r_c^3$, and that the nuclear wave function can be approximated by a product of A identical nucleon wave functions. Then the probability for a nucleon to get into the volume V_c is equal to

$$p = V_c \cdot \rho(r), \qquad (2)$$

where $\rho(r)$ is the relative nuclear density, $\int \rho(r) \cdot d^3 r = 1$. We used the Saxon-Woods potential

$$\rho(r) = \frac{\rho_0}{A} \cdot \left(1 + \exp\left(\frac{R-r}{d}\right)\right)^{-1},$$

where

$$R = 1{,}12 \cdot A^{1/3}\ \mathrm{fm}, \qquad d = 0.54\ \mathrm{fm}. \qquad (3)$$

The probability that k nucleons of A will get into the volume V_c is

$$P(k, A, r) = C_A^k \cdot p^k \cdot (1-p)^{A-k}, \qquad (4)$$

and for the average flucton number in the nucleus A we obtain

$$P(k, A) = \int \frac{d^3 r}{V_c} \cdot C_A^k \cdot (V_c \cdot \rho(r))^k \cdot (1 - V_c \cdot \rho(r))^{A-k}. \qquad (5)$$

(B) $q_k(x)$ is the quark-parton distribution in the flucton k. It can be estimated in the following way /5/: since the binding energy of quarks in the nucleon is much greater than that of nucleons in the nucleus, the interaction of the projectile particle with the flucton is reduced to its interaction with the quarks of a colourless triplet (at the great momentum transfer $t \gg 1$ GeV). Other quark triplets can be considered

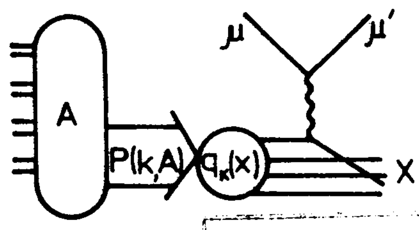

Fig.1. Deep inelastic scattering mechanism for the leptons at the nucleus A.

as passive spectators with the frozen quark-gluon degrees of freedom, i.e., as point-like objects (from force of habit we call them nucleons). Then the quark distribution in the flucton will be determined by the convolution of the nucleon quark distributions $q_N(x_q)$ with the nucleon distributions $N_k(x_N)$ in the flucton

$$\tilde{q}_k(a) = \iint_0^1 dx_q \cdot dx_N \cdot q_N(x_q) \cdot N_k(x_N) \cdot \delta(a - x_q \cdot x_N) \,. \tag{6}$$

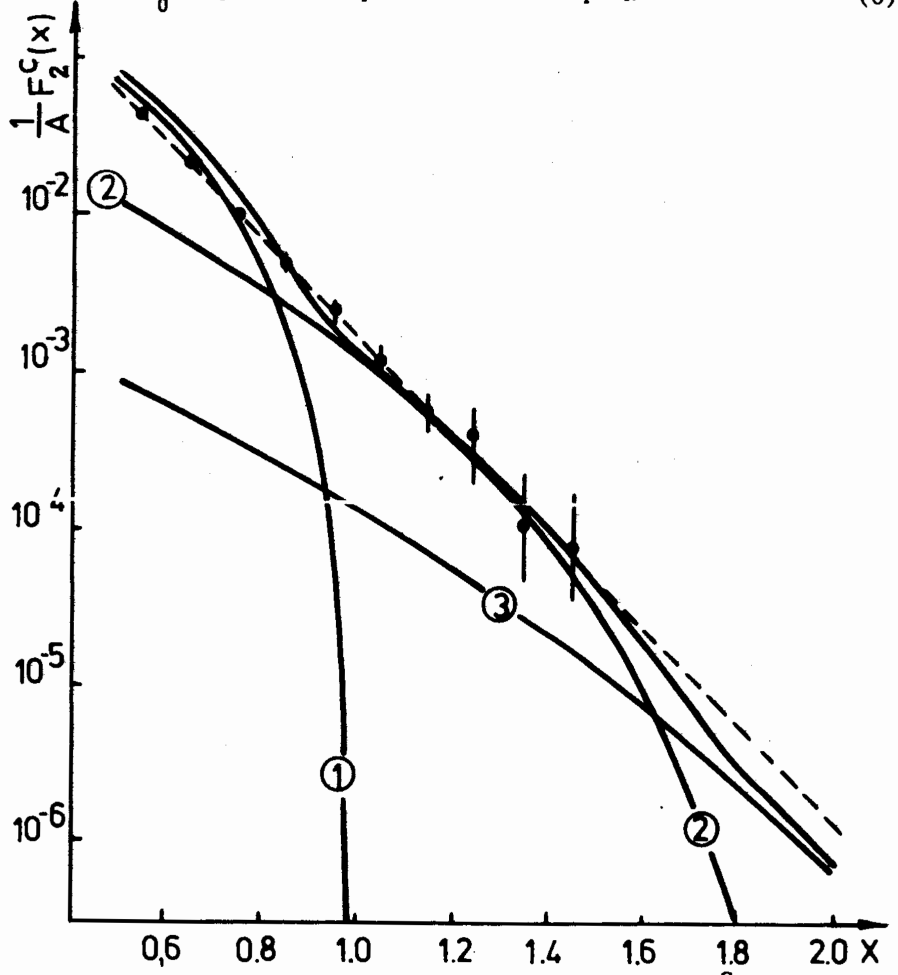

Fig.2. Comparison of the theoretical curve $F_2^C(x)$ (solid line) with the experimental data. Dashed line is a fit $F_2^C(x) = 2.15 \cdot \exp(-x/0.14)$. Curves with the numbers correspond to the one-nucleon, two-nucleon and three-nucleon structure functions.

In the limit $t \gg m_N$ the distribution $N_k(x)$ can be estimated as a part of the phase volume for one massless point-like nucleon

$$N_k(x) = \frac{k \cdot \Phi(x)}{\int dx \cdot \Phi(x)} \,,$$

where (7)

$$\Phi(x) \cdot dx = \int_1 \ldots \int_{k-1} \prod_{j=1}^{k} \frac{d^3P_j}{2 \cdot P_j^\circ} \cdot \delta(P - P_k - \sum_{j=1}^{k-1} P_j) \,,$$

$$P_k = x \cdot P \,.$$

The calculation of (7) provides

$$N_k(x) = k \cdot (2k-1) \cdot (2k-2) \cdot x \cdot (1-x)^{2k-3} \,. \tag{8}$$

Substituting (8) into (6) and using the approximation for $q_N(x)$ in the form

$$q_N(x) = C_q \cdot x^a \cdot (1-x)^b \tag{9}$$

(quantities C_q, a and b for proton are listed in the Table), one obtaines $(x = a/k)$

$$\tilde{q}_k(x) = q_N(x/k) \cdot (1 - x/k)^{2k-2} \cdot \frac{2k! \cdot b!}{2(2k+b-2)!} \times \tag{10}$$

$$\times\, F(a+b,\ 2k-2,\ 2k+b-1,\ 1-x/k),$$

where $F(a,b,c,z)$ - hypergeometric function.

Table

Proton structure functions:
$q(x) = C_q \cdot x^a \cdot (1-x)^b$

$q(x)$	a	b	C_q
$u(x)$	$-1/2$	3	2.19
$d(x)$	$-1/2$	4	1.23
$s(x) = \bar{u}(x) = \bar{d}(x) = \bar{s}(x)$	-1	7	0.25
$g(x)$	-1	5	3.0

Finally, taking into account the fact that the flucton contains $k \cdot Z/A$ protons and $k(A-Z)/A$ neutrons on the average, we get

$$u_k(x) = Z/A \cdot \tilde{u}_k(x) + (A-Z)/A \cdot \tilde{d}_k(x),$$
$$d_k(x) = Z/A \cdot \tilde{d}_k(x) + (A-Z)/A \cdot \tilde{u}_k(x). \qquad (11)$$

Thus, the structure function $F_2^C(x)$ (1) has the only free parameter r_c. The minimum square approximation for this function, using the experimental data [1] gives for r_c the value

$$r_c = 0.71 \pm 0.01 \text{ fm}. \qquad (12)$$

The comparison of the theoretical curve for $F_2^C(x)$ with the experiment is represented in Fig.2. Also the contribution of several first terms of (1) to the theoretical curve is shown. One sees that at $0 < x < 0.8$ the one-nucleon function gives the main contribution to (1), while at $0.8 < x < 1.6$ the two-nucleon function does, etc.

Thus, the flucton can actually be considered as a superdense fluctuation of the nuclear matter. The inclusion of the Fermi-motion of fluctons leads to a decrease in r_c and to a smoothing of the theoretical curve.

REFERENCES

1. Savin I.A. Review talk at VI Intern.Seminar on High Energy Physics Problems, Dubna, 1981, JINR, D1,2-81-728, p.223.
2. Efremov A.V. Particles and Nuclei, 1982, 13, p. 613.
3. Frankfurt L.L., Strikman M.I. Phys.Lett., 1982, 114B, p. 345.
4. Lukjanov V.K., Titov A.I. Particles and Nuclei, 1979, 10, p. 815.
5. Berlad G., Dar A., Eilam G. Phys.Rev., 1980, D22, p. 1547.

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Глубоконеупругое рассеяние лептонов на углероде в модели флуктонов

Обсуждаются результаты эксперимента BCDMS-коллаборации по измерению структурной функции углерода $F_2^c(x)$ при $x > 1$ для модели флуктонов.

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The Deep Inelastic Scattering of Leptons on the Carbon in the Flucton Model

The consequences of the experiment of the BCDMS collaboration, which performed a measurement of the carbon structure function $F_2^C(x)$ at $x > 1$ for the flucton model are discussed.

The investigation has been performed at the Laboratory of Theoretical Physics, JINR.

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