ON THE A-DEPENDENCE OF THE NUCLEAR STRUCTURE FUNCTIONS

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The A-dependence of the nuclear structure functions is described rather well within the framework of the quark-parton-flucton model of nucleus (*Acta Phys. Austriaca* **57**, 33 (1985), *Acta Phys. Austriaca* **57**, 239 (1985), *Acta Phys. Austriaca* **57**, 277 (1985), *Acta Phys. Pol.* **B17**, 401 (1985)).

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In recent years the EMC effect [5] attracts great attention to theoretical investigations of the quark structure of nuclei [6–15]. At SLAC [16] the ratio

$$R_A(x) = \frac{2}{A} F_2^A(x)/F_2^D(x)$$

is measured for various nuclei He^4, Be^9, C^{12}, Al^{27}, Ca^{40}, Fe^{56}, Ag^{108} and Au^{197}.

It is found that the obtained experimental data fulfill approximately the law

$$R_A(x) = A^{\alpha_A(x)}, \tag{1}$$

in which $\alpha_A(x)$ is a function of x and depends upon A.

In this paper we try to explain (1) within the framework of the model developed in [1–4]. As is given in [1] the nuclear structure function $F_2^A(x)$ reads

$$F_2^A(x) = \sum_{k=1}^{A} \beta_k^A x_k B_k(\lambda_k) \left[\left(\tfrac{1}{9} + \frac{z}{18A} \right) (1-x_k)^{6k-2} + \frac{\lambda_k}{9} \frac{(1-x_k)^{6k+2}}{1-(1-x_k)^4} + \frac{kZ\lambda_k}{(1-x_k)^2} S_k \right],$$

where β_k^A, $B_k(\lambda)$ and S_k are given as follows

$$\beta_k^A = N \frac{A!}{k!(A-k)!} \left(\frac{V_c}{AV_0} \right)^{k-1}$$

$V_c = \frac{4}{3}\pi r_c^3$, $V_0 = \frac{4}{3}\pi r_0^3$, $r_c = 0.84\,\mathrm{fm}$, $r_0 = 1{,}2\,\mathrm{fm}$, N is the normalization constant,

$$B_k^{-1}(\lambda) = \frac{1-\lambda}{6k(6k-1)} + \lambda\left[\frac{1}{4}\left(3\ln 2 - \frac{\pi}{2} - \frac{17}{42}\right) - \sum_{m=0}^{(3k-8)/2} \frac{1}{(4m+11)(4m+12)}\right]$$

for odd k,

$$B_k^{-1}(\lambda) = \frac{1-\lambda}{6k(6k-1)} + \lambda\left[\frac{1}{4}\left(\ln 2 + \frac{\pi}{2} - \frac{1}{2}\right) - \sum_{m=0}^{(3k-5)/2} \frac{1}{(4m+5)(4m+6)}\right]$$

for even k,

$$S_k = \frac{1}{4}\ln\frac{+(1-x_k)^2}{1-(1-x_k)^2} - \frac{1}{2}\sum_{m=1}^{(3k+1)/2} \frac{(1-x_k)^{2(2m-1)}}{2m-1}$$

for odd k and

$$S_k = \frac{1}{4}\ln\frac{1}{1-(1-x_k)^4} - \frac{1}{4}\sum_{m=1}^{3k/2} \frac{(1-x_k)^{4m}}{m}$$

for even k.

In our model the parameter λ characterizes the contribution of pairs of quarks, which, for k-flucton, has the form

$$\lambda_k = \exp(-k\mu^2/Q^2), \qquad 1 \leqslant k \leqslant A. \tag{2}$$

Let λ_A be the mean value of λ per one flucton of nucleus, defined by the equation

$$\sum_{k=1}^{A} \beta_k^A x_k B_k(\lambda_A)\left[\left(\frac{1}{g} + \frac{Z}{18A}\right)(1-x_k)^{6k-2} + \frac{\lambda_A}{g}\frac{(1-x_k)^{6k+2}}{1-(1-x_k)^4} + \frac{kZ\lambda_A}{(1-x_k)^2}S_k\right]$$

$$= \sum_{k=1}^{A} \beta_k^A x_k B_k(\lambda_k)\left[\left(\frac{1}{g} + \frac{Z}{18A}\right)(1-x_k)^{6k-2} + \frac{\lambda_k}{g}\frac{(1-x_k)^{6k+2}}{1-(1-x_k)^4} + \frac{kZ\lambda_k}{(1-x_k)^2}S_k\right].$$

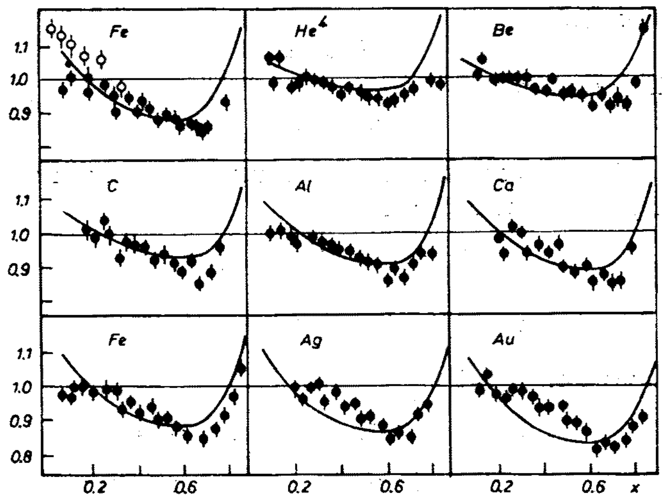

Fig. 1. Graphics of $R(x)$ for various nuclei. Data are given in [16]

It is clear that λ_A depends on A. For simplicity let us assume that

$$\lambda_A = \alpha A^\beta + \gamma.$$

The parameters α, β and γ are determined by fitting to experimental data. It is found that

$$\lambda_A = A^{0.065} - 0.5 \tag{3}$$

for $A > 2$, $\lambda_D = 0.5$.

Based on (3) the graphics of the function

$$\alpha_A(x) = \frac{1}{\ln A} \ln \left[\frac{2}{A} F_2^A(x, \lambda_A)/F_2^D(x, \lambda_D) \right] \tag{4}$$

are shown in Fig. 1 for various nuclei $A = He^4, Be^9, C^{12}, Al^{27}, Ca^{40}, Fe^{56}, Ag^{108}$ and Au^{197}.

As is seen in Fig. 1, the agreement between theoretical calculations and the experimental data is good enough.

Next let us discuss the physical significance of the results obtained above.

The formula (3) indicates that the contribution of sea quarks increases as we go from light to heavy nuclei. Let Q_A^2 be the mean value of Q^2 per one flucton of nucleus A, which is related to λ_A by the formula similar to (2)

$$\lambda_A = \exp(-\bar{\mu}^2/Q_A^2), \tag{5}$$

where $\bar{\mu}^2$ is a constant.

Then from the inequality

$$\lambda_A > \lambda_D$$

for $A > 2$ it follows that

$$Q_A^2 > Q_D^2$$

which leads to the inequality

$$R_A < R_D$$

between the mean radii of fluctons contained in nucleus A and in deuterium D, respectively.

On the other hand, (4) and (5) provide

$$F_2^A(x, Q_A^2) = A^{\alpha_A(x)+1} F_2^D(x, \xi_A Q_A^2) \tag{6a}$$

or

$$F_2^A(x, R_A) = \tfrac{1}{2} A^{\alpha_A(x)+1} F_2^D(x, \eta_A R_A) \tag{6b}$$

in which ξ_A, η_A depend on A and

$$\xi_A < 1, \quad \xi_D = 1, \quad \eta_A > 1, \quad \eta_D = 1.$$

It is clear that (6a) and (6b) are the selfsimilarity relations of nuclear structure functions.

It is worth to notice that Eq. (6a) is similar to that suggested by Close and coworkers [14],

$$F_2^A(x, Q^2) = F_2^N(x, \xi_A Q^2), \quad \xi_A > 1,$$

basing on the assumption of Jaffe's, that the scale of confinement of quarks within different nuclei may vary.

Thus, in our model λ_A plays the role of a structure constant of nucleus A; its physical significance is clear: it characterizes the contribution of sea quarks, averaged per one flucton of nucleus A and is calculated by means of (3).

Editorial note. This article was proofread by the editors only, not by the authors.

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