SOFT AND HARD QUARK COLLISIONS IN LARGE TRANSVERSE MOMENTUM HADRON-NUCLEUS PROCESSES

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The contribution of soft multiple constituent quark collisions to the inclusive spectrum of large transverse momentum P_T particles generating in hadron-nucleus reactions at high energies is studied. By analysing the reaction $pA \to \pi X$ it is shown that this contribution is considerable and determines basically the π meson spectra at $P_T \lesssim 3$ GeV/c, but it decreases at $P_T > 3$ GeV/c. The inclusion of both soft and hard quark collisions inside the nucleus allows one to describe quite satisfactorily the A dependence of these π meson spectra within a wide region of $P_T, P_T = 1 \div 6$ GeV/c. The quark confinement effect on the results of π meson spectrum calculations is studied.

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Recently quantum chromodynamics (QCD) has been successfully used for a quantitative description and prediction of the characteristics of hard processes at high energies, i.e. large transverse-momentum processes. A great number of hard processes is described in the framework of the quark-parton model using the quark distribution functions and fragmentation functions of quarks to hadrons [1]. The production of large transverse-momentum P_T particles in hadron-hadron interactions is of special interest. The production of large P_T hadrons in these processes is explained by the hard scattering of quark-partons with a subsequent fragmentation of them into hadrons. This mechanism is also applied to the particle production in hadron-nucleus processes at $P_T > 4$–5 GeV/c [4–7]. The application of the hard quark-quark scattering model or QCD for the analysis of inclusive spectra of lower P_T particles produced in such processes does not give the results which agree with the experimental data [6, 7]. The possible cause of such a discrepancy consists in the omission of the contribution of soft multiple quark collisions to particle spectra at $P_T < 4 \div 5$ GeV/c.

The present paper is intended to analyse the contiibution of soft multiple constituent quark collisions, occurring inside the nucleus, to the inclusive spectrum of final large P_T

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hadrons produced in hA → h'X reactions. The comparison of theoretical results with the experimental data of inclusive momentum spectra of π mesons, produced in the process pA → πX at $P_T = 1\div6$ GeV/c is given taking into account both soft and hard quark collisions. The analysis is performed both with the inclusion of the quark confinement and without. The results of these two approaches are compared.

We consider the production process of lagre P_T hadron, for example of $P_T > 1$ GeV/c. If the final hadron h' is emitted at large angle θ^* in the hadron-nucleon center of mass system, for example, $\theta^* \approx \pi/2$, the scattering angle of hadron in the rest system of nucleus θ_L will be small at high energies E_0 of the initial hadron. For instance, in the process pA → h'X at $E_0 = 300$ GeV, $\theta_L \approx 4.4°$, that is the produced hadron is emitted at small angle at the laboratory system (l.s.) but it gets large transverse-momentum. Therefore, it can be supposed that the final h' gets large transverse-momentum due to the multiple collisions of the initial hadron with nuclear nucleons. Such a mechanism has been used for the analysis of A dependence of inclusive momentum spectra of large P_T protons (P_T = 1–6 GeV/c) in the process pA → pX [8]; and it allowed to describe the experimental data [9] quite satisfactorily. However, since at high energies as it has been pointed out in Ref. [10], the strong interaction radius is comparable with the constituent quark radius, it is more correct to take into account quark scatterings rather than hadron scatterings occurring inside the nucleus. Moreover, the above mechanism of rescattering of the leading particle can hardly be applied for the description of inclusive momentum spectra of produced in p–A interaction π mesons [11].

We shall analyse the large P_T processes hA → h'X in the framework of the constituent quark model. They can be described by the model similar to the mechanism explaining the large P_T particle production in hard hadron processes [2, 3]. As it is shown in Fig. 1 every constituent quark of hadron h interacts with nucleus and then fragments into hadron h'. After the interaction with nucleus a quark of the initial hadron can get large P_T in two ways. Either with the help of hard quark-quark (q–q) collisions or by the use of soft multiple quark collisions occuring inside the nucleus. We notice that, as it has been shown in Ref. [7], the single hard q–q collisions are most probable and the contribution of multiple hard q–q rescatterings is negligible. First we shall analyse the second possibility assuming that each constituent quark of the initial hadron interacts with nucleus independently from each other. Further, we shall take into account quark confinement. Since we consider large P_T processes, then, as it has been shown in Ref. [12, 13], the recombination mechanism

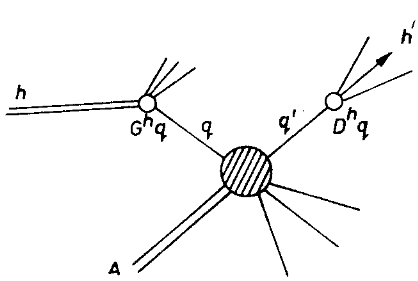

Fig. 1. Diagram of the process hA → h'X

of constituent quark and sea anti-quark with subsequent hadronisation cannot be applied to such processes. Therefore, we do not take into account this mechanism. According to the aforesaid and to Refs. [14, 23] the contribution $F^S_{hA} = Ed\sigma_{hA\to h'X}/d^3P$ to the inclusive large P_T hadron spectrum, for example, $P_T > 1$ GeV/c of the reaction hA → h'X due to the soft quark collisions inside the nucleus can be written in the following form:

$$F^S_{hA}(x, P_T) = x_R \sum_q \int \prod_{i=1}^{3} d^2P_{iT} \int_0^1 \prod_{i=1}^{3} dx_i G_{qh}(x_1, P_{1T})$$
$$f_{qA}(x_2, P_{2T}) D^h_q(x_3, P_{3T}) \delta(x - x_1x_2x_3) \delta^{(2)}(P_T - P_{1T} - P_{2T} - P_{3T}).$$

Here the following notation is introduced: $G_{qh}(x_1, P_{1T})$ is the distribution function of constituent quark in x_1 and P_{1T}; x_1 is the Feynman variable of quark in the h–N c.m.s., P_{1T} is its transverse-momentum; $f_{qA}(x_2, P_{2T}) \equiv d\sigma_{qA\to q'X}/d^3P_2$ is the inclusive spectrum of scattered quarks in the process qA → q'X as a function of the Feynman variable x_2 of quark q' and its transverse-momentum P_{2T}; $D^h_q(x_3, P_{3T})$ is the fragmentation function of quark q' into hadron h' (see Fig. 1); $x_R = \sqrt{x^2 + 4(P_T^2 + m^2_{h'})/S}$; x is the Feynman variable of the final hadron h' in the h–N c.m.s., P_T is its transverse-momentum and S is the square of total energy in the h–N c.m.s.

The summation in (1) is over all constituent quarks of the initial hadron h.

We notice that the dependence of the distribution and fragmentation quark functions both on X and on P_T is taken into account in expression (1).

As in Ref. [3] we shall present the functions $G_{qh}(x, P_T)$ and $D^h_q(x, P_T)$ in a factorised form:

$$G_{qh}(x, P_T) = \frac{x}{x_R} q(x) G_q(P_T), \qquad D^h_q(x, P_T) = \frac{x}{x_R} \tilde{D}_q(x) \tilde{f}_q(P_T); \tag{2}$$

where $q(x)$, $G_q(P_T)$ are the quark distribution functions in hadron h depending on x and P_T, respectively; $\tilde{D}_q(x)$ and $\tilde{f}_q(P_T)$ are the fragmentation functions of quark q' into hadron h' depending on x and P_T.

Since we take into account soft multiple quark collisions, that is the sequence of small transfer processes, the inclusive quark spectrum f_{qA} after the interaction with the nucleus is calculated in the approximation similar to the "optical" approach, as in Refs. [15, 16], but taking into account the P_T dependence of quark distribution functions:

$$f'_{qA} = \int G_{qh}(x_1, P_{1T}) f_{qA}(x_2, P_{2T}) \delta(x - x_1x_2) \delta^{(2)}(P_T P_{1T} P_{2T}) dx_1 dx_2 d^2P_{1T} d^2P_{2T},$$

$$f_{qA} = \sigma_{qA} \sum_{n=1}^{A} P_{qn} G^{(n)}_{qh}(x, P_T), \tag{3}$$

where

$$P_{qn} = \frac{1}{n!} \int (\sigma_{qN} T(b))^n \exp(-\sigma_{qN} T(b)) d^2b / \sigma_{qA}$$

is the probability for the n-multiple interaction of a quark with nuclear nucleons; σ_{qA} is the cross section of the inelastic interaction of a quark with nucleus, it can be calculated in the "optical" approach [15]; $T(b) = \int_{-\infty}^{\infty} \varrho(b, z) dz$; $\varrho(b, z)$ is the nuclear density; σ_{qN} is the cross section of the q–N scattering [15, 16]; $G^{(n)}_{qh}(x, P_T)$ is the quark distribution function after n interactions inside the nucleus. According to (2) $G^{(n)}_{qh}(x, P_T) = q^{(n)}(x)\, G^{(n)}_q(P_T) \dfrac{x}{x_R}$. The function $q^{(n)}(x)$ is calculated as in Refs. [14, 16]:

$$q^{(n)}(x) = \int_0^1 dx_1 \int_0^1 dx_2 q(x_1) W^{(n)}(x_2) \delta(x - x_1 x_2); \tag{4}$$

We have an analogous expression for $G^{(n)}_q(P_T)$:

$$G^{(n)}_q(P_T) = \int G_q(P_{1T}) \Phi^{(n)}(P_{2T}) \delta^{(2)}(P_T - P_{1T} - P_{2T}) d^2P_{1T} d^2P_{2T}. \tag{5}$$

Here $W^{(n)}(x)$ and $\Phi^{(n)}(P_T)$ are the probabilities of a quark to have the longitudinal momentum part x and the transverse-momentum P_T after n interactions with nuclear nucleons. They are calculated analogously:

$$W^{(n)}(x) = \int_0^1 dx_1 \int_0^1 dx_2 W^{(1)}(x_1) W^{(n-1)}(x_2)$$

$$* \,\delta(x - x_1 x_2) = \int_0^1 \prod_{i=1}^{n} W(x_i) \delta(x - \prod_{i=1}^{n} x_i) dx_i, \tag{6}$$

$$\Phi^{(n)}(P_T) = \int \prod_{i=1}^{n} \Phi(P_{iT}) \delta^{(2)}(P_T - \sum_{i=1}^{n} P_{iT}) d^2P_{iT}. \tag{7}$$

And then

$$W^{(1)}(x) \equiv W(x); \qquad \frac{1}{\sigma} \frac{d\sigma}{dx d^2P_T} = W(x)\Phi(P_T)$$

is the normalized to 1 differential cross section of the quark-nucleon interaction [16].

Taking into account the factorization (2) of the functions $G_{qh}(x, P_T)$ and $D^h_q(x, P_T)$, the expression (1) can be presented in the following form:

$$F^S_{hA}(x, P_T) = x\sigma_{qA} \sum_{n,q} P_{qn} F^{(n)}_1(x) F^{(n)}_2(P_T) \tag{8}$$

$$F^{(n)}_1(x) = \int_x^1 \frac{dx_1}{x_1} W^{(n)}(x_1) D_{0q}\left(\frac{x}{x_1}\right), \tag{9}$$

where

$$D_{0q}\left(\frac{x}{x_1}\right) = \int_{x/x_1}^1 \frac{dx_2}{x_2} q(x_2) \tilde{D}_q\left(\frac{x}{x_1 x_2}\right),$$

and

$$F^{(n)}_2(P_T) = \int G^{(n)}_q(P_{1T}) \tilde{f}_q(P_{2T}) \delta^{(2)}(P_T - P_{1T} - P_{2T}) d^2P_{1T} d^2P_{2T}. \tag{10}$$

Thus, with the quark distribution $G_{qh}(x, P_T)$ and fragmentation $D^h_q(x, P_T)$ functions and with the differential cross section of the quark-nucleon interaction, one can calculate using (8) the contribution of soft quark collisions inside the nucleus to the inclusive hadron spectrum in the reaction hA → h'X.

To estimate $F^S_{hA}(x, P_T)$ and compare it with the experimental data, we consider meason production processes in the p−A interaction, that is the reaction of type p+A → mesons +X. The x distribution of constituent quarks in a proton is given, for example, in Ref. [17]; it differs from the quark-parton (valence quarks) distribution mainly at small x. However, as it is shown in Refs. [18, 19], the interacting constituent quark has the following x distribution at $x \to 0$ $q(x) \approx x^{-\alpha_R(0)}$, where $\alpha_R(0)$ is the value of Regge trajectory at $t = 0$. In Refs. [18, 19] peripheral processes are connected with hard processes. Such a x behaviour at small x coincides with the valence quark distribution [2, 3] resulting from the deep inelastic lepton-nucleon scattering. Therefore, based on the results of Refs. [18, 19], we can use as $q(x)$ the distribution of valence quarks in a nucleon [2, 3]. According to Ref. [20] the quark momentum spectrum in the process qN → q'X can be taken the same as that in the reaction hN → h'X. Then, we choose the $W(x)$ and $\Phi(P_T)$ functions in the following form

$$W(x) = (\beta+1)x^\beta; \quad \Phi(P_T) = \frac{B^2}{2\pi}\exp(-BP_T);$$

here constants are defined from the conditions:

$$\int_0^1 W(x)dx = 1; \quad \Phi(P_T)d^2P_T = 1.$$

We choose quark distribution $G_q(P_T)$ and fragmentation functions depending on P_T in the following form [3]:

$$G_q(P_T) = \frac{b^2}{2\pi}e^{-bP_T}; \quad \tilde{f}_q(P_T) = \frac{B^2}{2\pi}e^{-BP_T}$$

they are normalized in the same way as $\Phi(P_T)$; the parameter b is connected with an average quark transverse-momentum in a nucleon [3]: $\langle P_{qT}\rangle = 2/b$, b is a free parameter since an average momentum of a constituent quark is unknown experimentally, though $\langle P_{qT}\rangle$ of a valence quark is known from deep inelastic l–N scattering [3]. We choose $b \approx B$ for the sake of simplicity of calculations. We define the quantity B from the successfull description of the experimental inclusive meson spectrum of the elementary process p+p → meson+X that has been calculated using (8) and assuming $n = 1$ in the summ. It turned out that B 5÷5.5 GeV/c^{-1}. The fragmentation function of a quark into a meson $\tilde{D}_q(x)$ has been taken from Ref. [2] and presented in the form: $xD_q(x) = \sum_{n=0}^{m} a_n x^n$. Under such a choice of $\Phi(P_T)$, $G_q(P_T)$ and $\tilde{f}_q(P_T)$ functions, the integration in (1) over d^2P_{iT} is performed completely. Expression (7) can be presented in the following form:

$$\Phi^{(n)}(P_T) = (2\pi)^{n-1}\int\prod_{i=1}\Phi(P_{iT})J_0(bP_{iT})J_0(bP_T)bdbd^2P_{iT}, \tag{11}$$

where $J_0(x)$ is the zeroth order Bessel function. Substituting $\Phi(P_T)$ into (11), we get:

$$\Phi^{(n)}(P_T) = \frac{B^2}{(2\pi)\Gamma(\frac{3}{2}n)} \left(\frac{B \cdot P_T}{2}\right)^{\frac{3}{2}n-1} K_{\frac{3}{2}n-1}(BP_T); \tag{12}$$

where $\Gamma(\alpha)$ is gamma function and $K_m(y)$ is the McDonald function. We notice, that the quark spectrum after n collisions with nucleons $\Phi^{(n)}(P_T)$ is the same as the proton spectrum in the reaction pA → pX after n multiple rescatterings of initial protons inside a nucleus [8]. The inclusion of the P_T dependence of a quark distribution in a hadron gives the following. Substituting $\Phi^{(n)}(P_T)$ into (5) and integrating (5) over d^2P_{iT}, we get the expression for the quark distribution function after n multiple quark collisions inside the nucleus $G_q^{(n)}(P_T)$:

$$G_q^{(n)}(P_T) = \frac{B^2}{(2\pi)\Gamma\left(\frac{3n+1}{2}+1\right)} \left(\frac{BP_T}{2}\right)^{\frac{3n+1}{2}} K_{\frac{3n+1}{2}}(BP_T). \tag{13}$$

Then substituting $G_q^{(n)}(P_T)$ and $\tilde{f}_q(P_T)$ into (10) and integrating (10) over d^2P_{iT}, we get the final expression for $F_2^{(n)}(P_T)$:

$$F_2^{(n)}(P_T) = \frac{B^2}{(2\pi)\Gamma(\frac{3}{2}n+3)} \left(\frac{BP_T}{2}\right)^{\frac{3}{2}n+2} K_{\frac{3}{2}n+2}(BP_T); \tag{14}$$

We notice that the McDonald function has the following asymptotic form at large P_T, even at $P_T \gtrsim 2$ GeV/c:

$$K_m(BP_T) \underset{BP_T \gg 1}{\approx} \left(\frac{\pi}{2BP_T}\right)^{1/2} e^{-BP_T}$$

for any m. Then expression (14) acquires quite a simple form.

Unfortunately, the function $F_1^{(n)}(x)$ appearing in (8) has no analytical expression and the integration in (9) over dx_1 has been performed numerically.

We should like to note that expression (1) is written under the assumption that every constituent quark of the initial hadron interacts with nuclear nucleons independently from each other. This assumption is right at small transverse-momentum in the p–A collisions producing mesons when initial quarks do not move far from each other after the interaction with the nucleus. In our case we should take into account the fact that due to the quark confinement quarks cannot move far from each other after the penetration through the nucleus. We take into account this phenomenon in the framework of the colour flux-tube model [21–25]. According to this model the penetration of the initial quark through the nucleus can be considered as follows. After the first collision of the initial quark with a quark of nuclear nucleon the constant chromostatic field forms a colour tube between the scattering quark and the quark-spectator at some moment. For simplicity we assume that the string is formed between the quarks and after some time a q–$\bar{q}$ pair is produced from the vacuum, then the string is broken and the process of the string formation and of the pair q–$\bar{q}$ production repeats [22–24]. The probability w for the pair q–$\bar{q}$ production per unit time per unit string length is calculated in Refs. [22–25]. Then, the vacuum persistence probability per length v between quarks at the time t will have the form [21, 22]: $\mathscr{P} = e^{-wrt}$. In our case the probability that the initial quark scatters n times inside the nucleus and at some time the pair q–$\bar{\text{q}}$ is not produced:

$$\mathscr{P}_n = e^{-wr_nt_n}$$

here r_n is the distance between the n multiple scattered quark and its initial direction, t_n is the time during which the initial quark collides n times with quarks of nuclear nucleons; in the system $\hbar = c = 1$; $t_n \approx nr_0$, where r_0 is an average distance between nuclear nucleons. $r_n \approx nr_0 \sin\theta_L$, θ_L is the laboratory scattering angle of final meson in the reaction p+A → meson+X. It should be noticed that we calculate $\mathscr{P}_n$ approximately in order to estimate how the inclusive spectrum calculated using (8) depends on the quark confinement. Then, we must multiply the passage probability of the initial quark through the nucleus without an additional pair production $\mathscr{P}_n$ by the n multiple scattering probability inside the nucleus. Then, we get the following expression instead of (8):

$$F_{\text{hA}} = x\sigma_{\text{qA}} \sum_{n,\text{q}} P_{\text{q}n}\mathscr{P}_n F_1^{(n)}(x)F_2^{(n)}(P_T). \tag{15}$$

The physical meaning of the expression (15) is that the decrease of the initial quark beam passing through the nucleus due to the possible quark-antiquark pair production mentioned above is taken into account.

We shall analyse now the quantitative contribution of soft quark collisions to the inclusive π meson spectrum at $P_T \gtrsim 1$ GeV/c produced in the reaction pA → πX. The ratio of this experimental π meson spectrum at $E_0 = 300$ GeV, $\theta_L = 77$ mrd to F^S_{PA} for A = ^{9}Be calculated according to (8) as a function of the dependence P_T without the quark confinement is shown in Fig. 2. It is seen from Fig. 2 that the theory agrees with the exper-

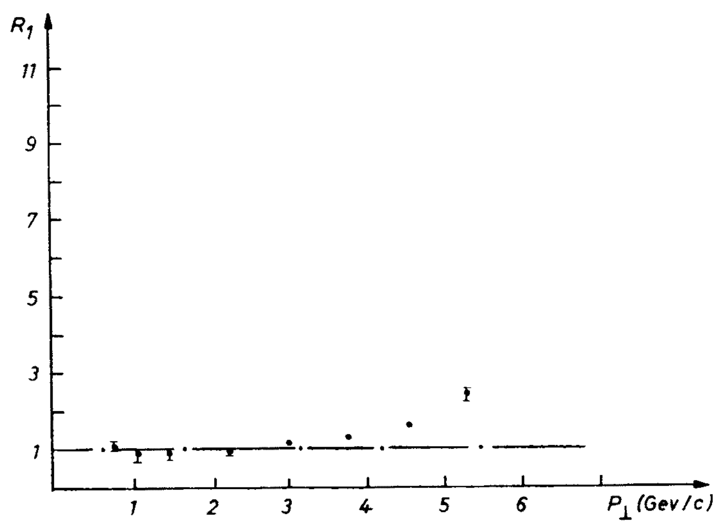

Fig. 2. The P_T dependence of $R_1 = F^{\text{exp}}_{\text{pA}}/F^S_{\text{pA}}$; $F^{\text{exp}}_{\text{pA}}$ and F^S_{pA} are the experimental and calculated inclusive meson spectra, respectively, at $E_0 = 300$ GeV, $\theta_L = 77$ mrd, A = ^{9}Be

iment quite satisfactorily at $P_T \lesssim 3$ GeV/c but at $P_T > 3$FeV/c the contribution of soft quark collisions decreases and at $P_T \geqslant 6$ GeV/c it vanishes. We notice that at first the constituent quark distribution function has been used as $q(x)$ [17], then as $q(x)$ the valence quark distribution function [2, 3], resulting from deep inelastic l–N scattering experiments has been used. The results obtained differed rather slightly.

The ratios $R_2 = F^C_{pA}/F^S_{pA}$ of the contributions of soft quark collisions without or with taking into account the quark confinement for the nuclei ^{9}Be and ^{47}Ti, respectively, are presented in Fig. 3. It is seen from this figure that with increasing P_T the contribution of

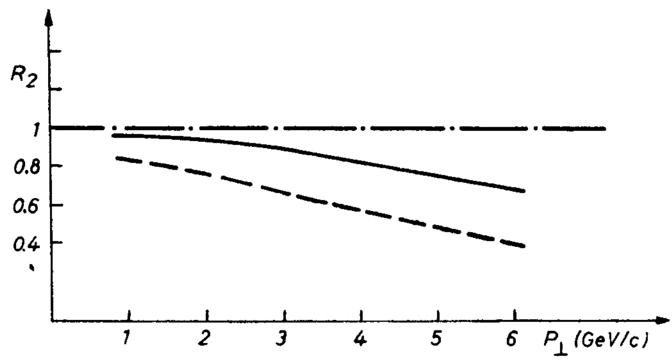

Fig. 3. The P_T dependence of $R_2 = F^c_{pA}/F^S_{pA}$ the solid curve corresponds to the case when A = ^{9}Be, the dashed curve when A = ^{47}Ti

F^S_{pA} especially for heavy nuclear targets decreases. This is due to the fact that the inclusion of the quark confinement, as it is seen from the expression for $\mathscr{P}_n$, decreases considerably the quark multiple rescattering contributions, which are small for light nuclei and are not small for heavy ones.

As it is shown in Refs. [6, 7] hard quark collisions, mainly simple, give a considerable contribution at $P_T > 3$ GeV/c and at $P_T \gtrsim 5$–6 GeV/c this contribution is determining to the second hadron spectrum, in our case to the inclusive spectrum of the p$-$A interaction produced π mesons. The spectrum part, caused by simple hard q–q scatterings $F^H_{pA}(x, P_T)$, is presented in the following form [6, 7]:

$$F^H_{pA}(x, P_T) \approx AF^H_{pp}(x, P_T) \tag{16}$$

where A is the atomic number of the nucleus, $F^H_{pp}(x, P_T)$ is the invariant inclusive hadron spectrum of the reaction p+p $\to$ meson+X, caused by hard q–q collisions, $F^H_{pp}(x, P_T)$ can be calculated at $P_T \gtrsim 3$ GeV/c, using either QCD or the semiphenomenological hard scattering model [2, 3]. According to the model [2]:

$$F^H_{pp}(x, P_T) = I(x_T, \theta^*) \frac{1}{P_T^8}\,. \tag{17}$$

Here $I(x_T, \theta^*)$ is the function depending slightly on x_T, which has been calculated in Ref. [2], where $x_T = 2P_T/\sqrt{S}$; S is the square of the total energy, θ^* is the angle of π-meson scattering in the p–p c.m.s. Substituting (17) into (16) we find the contribution of F^H_{pA}.

Proceeding from the aforesaid the inclusive π meson spectrum in the reaction $pA \to \pi X$ $F_{pA}(x, P_T)$ can be presented at $P_T \gtrsim 1$ GeV/c approximately in the form of incoherent sum of contributions of soft and hard quark collisions inside the nucleus:

$$F_{pA}(x, P_T) = F^S_{pA}(x, P_T) + F^H_{pA}(x, P_T). \tag{18}$$

As an example, we compare the A dependence of inclusive π meson spectra, calculated by (18), with the experimental data [9] for the reactions $pA \to \pi^+X$ at $E_0 = 300$ GeV, $\theta_L = 77$ mrd, $P_T = 1$–6 GeV/c. The calculated and experimental values [9] of $\alpha = \ln \frac{F_{pA_1}}{F_{pA_2}} \Big/ \ln \frac{A_1}{A_2}$; $A_1 = {}^9\mathrm{Be}$, $A_2 = {}^{47}\mathrm{Ti}$ are shown in Fig. 4. The solid curve in Fig. 4 is the results of calculation without the quark confinement, the dashed curve is the results obtained allowing for the quark confinement.

It is seen from Fig. 4 that the theory agrees fairly well with experiment in a wide P_T region if one neglects the quark confinement, that is assumes that quarks of the initial hadron rescatter inside the nucleus independently from each other. As it has been mentioned above, we have taken the quark confinement into account very approximately. In particular, the probability value of the q–$\bar{q}$ pair production from vacuum has been taken from Ref. [25]. There it was calculated for the free particle interaction. However, as it is shown in Ref. [26] the q–$\bar{q}$ production probability in the hadron-nucleus interaction must be less than the corresponding probability in the hadrron-hadon collision. Therefore, the vacuum persistence probability $\mathscr{P}_n$ is underestimated in our calculaцions. Furthemore, we do not take into account the contribution of vacuum producing q–$\bar{q}$ pairs to the final π meson spectrum, because of the calculational difficulties. Therefore, the dashed curve in Fig. 4 means the lower limit of the confinement effect.

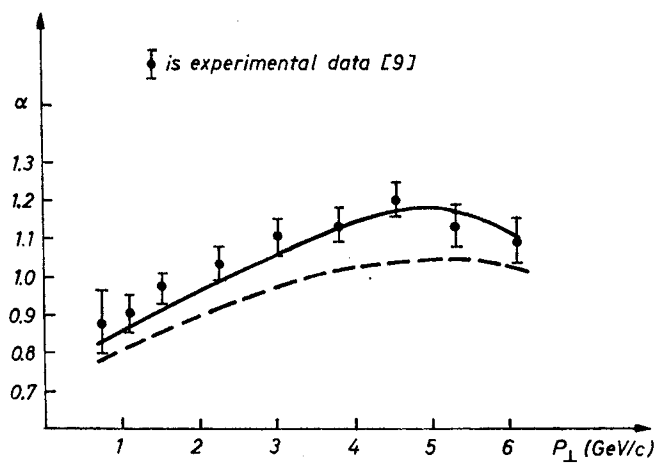

Fig. 4. The P_T dependence of $\alpha = \ln \frac{F_{pA_1}}{F_{pA_2}} \Big/ \ln \frac{A_1}{A_2}$; $A_1 = {}^9\mathrm{Be}$, $A_2 = {}^{47}\mathrm{Ti}$; the solid curve is the result of calculation without the quark confinement; the dashed curve is the result obtained taking into account the quark confinement

Thus, the investigation performed has shown the following. In analysing large P_T hadron-nucleus processes the contribution of soft multiple constituent quark collisions inside a nucleus can be taken into account. It is considerable and determines the inclusive spectrum of hadrons, produced in reactions hA → h'X at transverse-momentum $P_T \lesssim 3$ GeV/c, and at $P_T > 3$ GeV/c it decreases. The inclusion of both soft and hard quark collisions inside the nucleus allows one to describe the A dependence of the inclusive spectra of produced particles, particularly, π mesons in the p–A interaction, observed experimentally [9] at P_T = 1–6 GeV/c. If the quark confinement is taken into account, the results of calculation are decreased slightly quantitatively but not changed qualitatively.

Certainly, the present investigation is to be continued. We think that the analysis of the contribution of soft quark collisions to the spectra of large P_T leptons and hadron pairs, produced in the hadron-nuclei processes, is of special interest.

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