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ANTIQUARK DISTRIBUTIONS IN PION AND NUCLEON

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Relation between the antiquark distributions in pion and nucleon, based on the π -exchange hypothesis, is derived. The q-distributions in proton are calculated with the data on the valence antiquark distribution in pion as input. Results of the calculation agree with the experimental data. The role of the peripheral mechanism in formulation of the initial conditions for the chromodynamical evolution equations is discussed.

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I. Introduction

Hard processes are widely used for the investigation of the internal structure of hadrons. These processes are described in terms of short distance interactions and allow one to obtain an information on distributions of the point-like constituents (partons) in hadrons. It is assumed usually that each hadron is characterized by the distribution functions of different partons (quarks, antiquarks, gluons). Generally speaking, these distributions depend on the resolution of the measurement of hadronic structure, i.e. on the value of the square of the 4-momentum Q^2 for the given hard process.

In the framework of the QCD-perturbation theory it is possible to find the relation between these distributions for different $Q^2 \gg r_c^{-2}$ (where r_c is the

confinement radius). For calculation of the distributions it is however necessary to make a hypothesis on the form of the distributions at some fixed value Q_0^2. This is possible usually only for $Q_0^2 \sim r_c^{-2}$ (for example, in the valence quarks model), i.e. in the region where the perturbation theory is inapplicable.

Distributions of partons in hadrons are usually obtained from the data on some hard process, for example, deep inelastic scattering of leptons, and then they are used in calculations of other hard processes.

The aim of this work is to find a relation between antiquark ($\bar{q}$) distributions in pion and nucleon.

It has been shown in papers [1-3] that it is possible to relate cross sections of hard processes in NN and πN interactions, using the π -exchange model. This has been demonstrated for massive lepton pair production processes [1], J/ψ -meson production [2] and for production of hadrons with large transverse momenta [3].

The success of this description interpreted in terms of the quark-gluon approach means that a significant portion of antiquark in nucleon with relatively small fraction of total momentum ($x_{\bar{q}} \lesssim 0.3$) are due to the dissociation of this nucleon to a nucleon (or Δ -isobar) and π-meson, which is a source of $\bar{q}$ (see fig. 1).

It should be noted that the π -meson exchange in this model is understood in some generalized sense, because the square of the invariant momentum transfer $|t|$ can be rather large ($|t| \sim$ 1-2 GeV^2). For small values of $|t|$ the π -exchange is dominant, while for larger values of $|t|$ other exchanges (ρ, ω, ...), multipionic exchanges, absorbtion corrections, etc. can be important. Some of these effects are taken into account by the introduction of form factors (determined from experiment) into π -exchange amplitude. Thus we will speak of the "effective" π -exchange, having in mind the virtual hadronic system, which for small values of $|t|$ is well approximated by the pion exchange. It is important that the π -exchange allows one to determine the absolute normalization of cross sections at small values of $|t|$ and normalization at $|t| \sim 0.5 - 1$ GeV^2 is fitted with the parameters describing the off-shell dependence of amplitudes.

It is possible to relate the cross section of hard processes for proton and pion beams using the model of "effective" π -exchange (see fig. 2 for deep inelastic leptoproduction and fig. 3 for Drell-Yan process). On the other hand these cross sections can be described in terms of the quark-parton model. This leads to the relation between the antiquark distributions in nucleon and pion.

It is shown in Sections 2 and 3 that analysis of deep inelastic process and Drell-Yan process leads to the same relation between the structure functions of nucleon and pion, in spite of the kinematical distinctions of these processes. The probabilistic interpretation of the π -exchange mechanism is discussed. In Section 4 the results of numerical calculations of $\bar{q}$ -distribution in proton are given. They agree with the experimental data. Role of the peripheral mechanism in formulation of the initial conditions for the QCD evolution equation is discussed at the end of the paper.

2. Deep inelastic scattering

Consider the process of deep inelastic leptoproduction on nucleon $\ell N \to \ell' X$. We are interested in the process of scattering on antiquark of nucleon, i.e. in the following combinations of structure functions

$$\bar{u}^N(x) = \frac{1}{4}\left(\frac{1}{x} F_2^{\nu p}(x) + F_3^{\nu p}(x)\right) \tag{1a}$$

$$\bar{d}^N(x) = \frac{1}{4}\left(\frac{1}{x} F_2^{\bar{\nu} p}(x) + F_3^{\bar{\nu} p}(x)\right) \tag{1b}$$

The assumption that these processes are described by the π--exchange diagrams of fig. 2 leads to the following relation between the structure functions of nucleon and π-meson

$$W^{N}_{\mu\nu}(p_N, q) = \sum_R \int g^2_R(t) G^2_R(t) W^{\pi}_{\mu\nu}(\tilde{p}_\pi, q) \frac{d^3 p_R}{2E_R(2\pi)^3} \qquad (2)$$

where p_N and $\tilde{p}_\pi$ are the momenta of nucleon and virtual pion; p_R, E_R are the momentum and energy of particle $R = N, \Delta$; t - is the square of the virtual pion mass, $g_R(t)$ are the πNR vertices which are written down in Appendix. The functions $G_R(t)$ include the propagator of π -meson and the dependence of vertices and $W^{\pi}_{\mu\nu}$ on the square of the virtual pion mass (in the following we will describe them as form factors). For numerical calculations we use the same form of these functions as in ref. [1], where production of massive lepton pairs has been described. The corresponding formulae are given in Appendix.

Structure functions $W^{N,\pi}_{\mu\nu}$ are determined by the standard expressions

$$\begin{aligned} W^{N}_{\mu\nu}(p_N, q) = &-(g_{\mu\nu} - q_\mu q_\nu / q^2) \cdot 2F_1(x, q^2) + \\ &+ \left(p_{N\mu} - \frac{\nu}{q^2} q_\mu\right)\left(p_{N\nu} - \frac{\nu}{q^2} q_\nu\right) \frac{2}{\nu} F_2(x, q^2) - \\ &- i\epsilon_{\mu\nu\sigma\lambda} p_{N\sigma} q_\lambda \frac{1}{\nu} F_3(x, q^2) \end{aligned} \qquad (3)$$

where

$$\nu = 2(p_N \cdot q), \quad Q^2 = -q^2, \quad x = Q^2/2\nu .$$

For the process of deep inelastic scattering on π --meson the formula has the same structure with a substitution of ν and x by $\tilde{\nu}=2(\tilde{p}_{\pi}\cdot q)$ and $\tilde{x}=Q^2/2\tilde{\nu}$.

It is convenient to use as integration variables the Feynman variable of π -meson $x_{\pi}=\tilde{p}_{\pi\parallel}/p_N$, defined in the c.m. system of produced hadrons and the square of the momentum transfer t . The following approximate ($s \gg m_i^2$) kinematical relations for these variables take place

$$x_{\pi} \simeq \tilde{\nu}/\nu = \frac{\tilde{s}+Q^2}{s+Q^2} , \tag{4}$$

$$\begin{aligned} t &\simeq -\frac{p_{R\perp}^2}{1-x_{\pi}} + \tau_R(x_{\pi}) = \\ &= -\frac{p_{R\perp}^2}{1-x_{\pi}} - x_{\pi}\left(\frac{m_R^2}{1-x_{\pi}} - m_N^2\right) , \end{aligned} \tag{5}$$

where $\tilde{s}$ and s are the squared masses of systems, produced in $\nu\pi$ and νN -collisions, correspondingly , τ_R is the square of the minimal momentum transfer for production of particle $R=N,\Delta$ with the momentum $p_{R\parallel}=p_N(1-x_{\pi})$. Phase space volume can be written in terms of these variables as follows

$$\frac{d^3p_R}{E_R} \simeq \pi dx_{\pi} dt$$

Introducing the function

$$w_{\pi/N}(x_{\pi}) = \frac{x_{\pi}}{16\pi^2} \sum_R \int_{-\infty}^{\tau_R(x_{\pi})} dt\, g_R^2(t) G_R^2(t) \tag{6}$$

and isolating the tensor structures in the right-hand and left-hand parts of eq. (2) we obtain the following relation

$$\left\{F^{N}(x)\right\}=\int_{x}^{1} dx_{\pi}\, W_{\pi/N}(x_{\pi})\left\{F^{\pi}(x/x_{\pi})\right\}, \tag{7}$$

where $\left\{F^{\pi,N}(x)\right\}$ denotes any of the structure functions $xF_1^{\pi,N}(x)$, $F_2^{\pi,N}(x)$ or $xF_3^{\pi,N}(x)$

Eq. (7) and equalities (1a,b) lead to the relation between the antiquark distributions in nucleon and π -meson

$$\bar{q}^{N}(x)=\int_{x}^{1}\frac{dx_{\pi}}{x_{\pi}}\, W_{\pi/N}(x_{\pi})\,\bar{q}^{\pi}(x/x_{\pi}), \tag{8}$$

where $\bar{q}^{N,\pi}(x)$ are the distribution functions of $\bar{u}$ and $\bar{d}$ quarks in nucleon and pion correspondingly.

3. Drell-Yan process

Consider now the processes of lepton pair production in NN and πN collisions. Analysis of these reactions also allows one to obtain an information on the q and $\bar{q}$ - distributions in nucleon and pion [4].

For NN-collisions an antiquark with momentum fraction x_1 and a quark with momentum fraction x_2 (or with interchange of momenta $x_1 \rightleftarrows x_2$) annihilate and produce a leptonic pair with mass M and rapidity y. These variables are connected to x_1, x_2 by the kinematical relations

$$x_1=\sqrt{\tau}\, e^{y}, \quad x_2=\sqrt{\tau}\, e^{-y}, \tag{9}$$

where

$$\tau = M^2/s \tag{10}$$

The cross section has the form

$$\frac{d\sigma^{NN}}{dM\,dy} = \frac{8\pi\alpha^2}{9M^3}\sum_f z_f\left[x_1\bar{q}_f^N(x_1)\cdot x_2 q_f^N(x_2) + (x_1 \rightleftarrows x_2)\right] \tag{11}$$

(z_f is the charge of the f-ty pe quark).

For πN collisions the same formulae are valid with the only difference, that the main contribution to the cross section (for not too small $x_2 \gtrsim 0.05$) comes from an annihilation of an antiquark of π-meson with a valence quark of nucleon and contribution of the process $q^\pi + \bar{q}^N \to \gamma^*$ can be neglected

$$\frac{d\sigma^{\pi N}}{dM\,d\tilde{y}} = \frac{8\pi\alpha^2}{9M^3}\sum_f z_f\left[\tilde{x}_1\bar{q}_f^{\pi}(\tilde{x}_1)\cdot\tilde{x}_2 q_f^N(\tilde{x}_2)\right]. \tag{12}$$

For NN collisions we are interested in the region of such values of $\tau = M^2/s$, where an annihilation of a sea antiquark with a valence quark of nucleon is important. In terms of the π -exchange mechanism this process is described by two diagrams of fig. 2. The contribution of these diagrams can be written in the form

$$\frac{d\sigma^{NN}(s,y)}{dM\,dy} = \int g_R^2(t)\,G_R^2(t)\left[\frac{\tilde{s}}{s}\,\frac{d\sigma^{\pi N}(\tilde{s},\tilde{y})}{dM\,d\tilde{y}}\right]\frac{d^3p_R}{2E_R(2\pi)^3} + \tag{13}$$
$$+\,(\mathrm{symm.})$$

where s is the colliding nucleons c.m.energy squared; p_N is the momentum of the incident nucleon; p_R, E_R are the momentum and energy of particle $R = N, \Delta$ in this frame; $\tilde{s}$ is the square of invariant mass of πN --system.

Functions $g_R(t)$ and $G_R(t)$ have the same meaning as in Section 2 (see eqs. (A.1), (A.3) of Appendix).

Let us introduce the same variables $x_\pi = p_{\pi\parallel}/p_N$ and t as in Section 2, taking into account that for the process considered eq. (4) has the form

$$x_\pi \simeq \tilde{s}/s \tag{4a}$$

and eq. (5) is unchanged.

Rapidities y and $\tilde{y}$ in eq. (13) are defined in the overall c.m. reference frame and in the rest frame of πN -system, correspondingly. Kinematically allowed regions of y and $\tilde{y}$ are determined by the conditions $-y_0 < y < y_0$ and $-\tilde{y}_0 < \tilde{y} < \tilde{y}_0$, where

$$y_0 = \ln 1/\sqrt{\tau} \quad , \quad \tilde{y}_0 = \ln 1/\sqrt{\tilde{\tau}} \; , \tag{14}$$

$$\tilde{\tau}/\tau = s/\tilde{s} \simeq 1/x_\pi \quad . \tag{15}$$

The left boundaries of these distributions coincide (see fig. 4) thus we have

$$\tilde{y} = y + (y_0 - \tilde{y}_0) = y + \tfrac{1}{2}\ln 1/x_\pi \quad . \tag{16}$$

The minimal value of x_π in the integral (13) can be determined by the substitution $\tilde{y} = \tilde{y}_0$ into eq. (16). This gives

$$x_{\pi\,min} = \sqrt{\tau}\, e^{y} = x_1 \tag{17}$$

As a result relation (13) takes the form

$$\frac{d\sigma^{NN}(s,y)}{dM\,dy} = \int_{x_{\pi min}}^{1} dx_\pi\, w_{\pi/N}(x_\pi) \frac{d\sigma^{\pi N}(\tilde{s},\tilde{y})}{dM\,d\tilde{y}} + (y \to -y) \tag{18}$$

where $\tilde{s}$ and $\tilde{y}$ are defined by eq. (4a) and (16) and function $w_{\pi/N}(x_\pi)$ is defined by eq. (6) in Section 2.

Substituting equality (18) into eqs. (11), (12), which express the cross sections in terms of quark distributions and taking into account kinematical relations

$$\tilde{x}_2 = x_2 \quad , \quad \tilde{x}_1 = x_1 / x_\pi \tag{19}$$

we obtain the relation between the distributions $\bar{q}^N(x)$ and $\bar{q}^\pi(x)$, which coincides with eq. (8).

4. Probabilitistic interpretation

The diagrams of Figs. 2 and 3 were calculated in different kinematics. For example in deep inelastic process the upper limit for a variable $\tilde{p}_\pi$ is equal to $\sqrt{s}/2$, while for Drell-Yan process it equals $(s-M^2)/2\sqrt{s}$ and the lower limit of integration depends on pair rapidity y etc. However it is easy to see that only the common part of both diagrams, shown in fig. 1, is relevant for derivation of the relation between antiquarks distributions.

It is important that for this diagram the antiquark is on the mass shell (for parton model) or close to it $(p_{\bar{q}}^2 \ll Q^2)$ for QCD case.

Let us note that though we have used the S-matrix approach and have integrated over the squared mass of the virtual pion, the final structure of eq. (18) allows the probabilistic interpretation, analogous to the one of the parton model and characteristic for the noncovariant perturbation theory formalism.

From this point of view a probability $\bar{q}^N(x)dx$ to find an antiquark with the momentum fraction in the region between x and $x+dx$ in a nucleon is determined by the integral of the product of the probability $W_{\pi/N}(x_\pi)dx_\pi$ of nucleon dissociation into a pion with the momentum fraction in the interval x_π and $x_\pi+dx_\pi$ and a system R and the probability $\bar{q}^\pi(x/x_\pi)\,dx/x_\pi$ to find an antiquark with the momentum fraction in the interval x/x_π and $(x+dx)/x_\pi$ in a π-meson, i.e.

$$\bar{q}^N(x)\,dx = \int_x^1 dx_\pi\, W_{\pi/N}(x_\pi)\,\bar{q}^\pi(x/x_\pi)\,d(x/x_\pi) \tag{20}$$

This formula can be rewritten in the form

$$x\bar{q}^N(x)\,dx = \int_x^1 dx_\pi\; x_\pi W_{\pi/N}(x_\pi)\,(x/x_\pi)\,\bar{q}^\pi(x/x_\pi)\,d(x/x_\pi) \tag{21}$$

and can be interpreted as the fact that the part of a nucleon momentum in the interval $(x, x+dx)$ carried by an antiquark is equal to the integral of a product of the pion momentum fraction in an interval $(x_\pi, x_\pi+dx_\pi)$ and the fraction of an antiquark momentum in pion in the interval $(x/x_\pi, (x+dx)/x_\pi)$.

So the value $w_{\pi/N}(x_\pi)$ can be interpreted as the π-meson density in a nucleon when it dissociates to a π-meson and a system R . The integral of this function

$$n_{\pi/N} = \int_0^1 w_{\pi/N}(x_\pi)\, dx_\pi \tag{22}$$

characterizes the mean number of "effective" pions in nucleon *) and the quantity

$$X_{\pi/N} = \int_0^1 x_\pi\, w_{\pi/N}(x_\pi)\, dx_\pi \tag{23}$$

corresponds to the mean fraction of the nucleon momentum carried by a π-meson.

Integration of formula (21) leads to the following relation

$$X_{\bar q/N} = X_{\bar q/\pi} \cdot X_{\pi/N} \tag{24}$$

where $X_{\bar q/N} = \int_0^1 x\bar q^N(x)\, dx$ and $X_{\bar q/\pi} = \int_0^1 x\bar q^\pi(x)\, dx$ are the momentum fractions carried by antiquarks in proton and π-meson correspondingly.

An account of charge of the emitted π-meson is equivalent to the introduction of several functions

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*) It is worth to emphasize that we consider now only the π-mesons which take part in the first stage of multiperipheral fluctuation. The total number of mesons produced in the development of the multiperipheral chain grows as a logarithm of energy.

$$w_{N\to\pi^k R}(x_\pi)=\frac{x_\pi}{16\pi^2}\int g^2_{\pi^k NR}(t)\,G_R^2(t)\,dt \ , \qquad (25)$$
$$(R=N,\Delta\ ;\ k=+,-,0)$$

and the corresponding antiquark distribution functions $\bar{u}^{\pi^k}(x)$, $\bar{d}^{\pi^k}(x)$.

The connection between the antiquark distribution in proton and pion is determined by Eq. (8) where $w_{\pi/N}(x_\pi)$ can be expressed in terms of the probabilities $w_{p\to\pi^0 p}(x_\pi)$ and $w_{p\to\pi^-\Delta^{++}}(x_\pi)$ and the isotopic coefficients

$$w_{\pi/N}(x_\pi)=w^{(N)}(x_\pi)+w^{(\Delta)}(x_\pi)=3w_{p\to\pi^0 p}(x_\pi)+2w_{p\to\pi^-\Delta^{++}}(x_\pi) \qquad (26)$$

This formula takes into account the nucleon dissociation into the πN and $\pi\Delta$ systems only. Generally speaking, it is necessary to take into account a possible production of a system R with larger masses (πN , $K\Lambda$) etc.). It follows from Eq. (5) that the value of $\tau_R(x_\pi)$ grows when the mass m_R increases, so the contribution of larger masses ($m_R^2 \gtrsim 2$ GeV^2) in formula (6) is concentrated in the region of small x_π and therefore influences the $\bar{q}^N(x)$ distribution only in the region of very small x . The numerical estimates of the large mass contribution $w^{(L.M)}(x_\pi)$ are given in Section 4.

4. Numerical results

In this Section we give the numerical estimates for the antiquark distributions in nucleon, calculated with the use of form factors from ref. [1]. Formulae for the form factors $G_N(t)$ and $G_\Delta(t)$ and the values of parameters are given in Appendix.

The distributions $w^{(N)}(x_\pi)=3w_{p\to\pi^0 p}(x_\pi)$ and $w^{(\Delta)}(x_\pi)=2w_{p\to\pi^-\Delta^{++}}(x_\pi)$ are shown in fig. 5. Full curves are calculated with form factors (A.3), (A.4) and dashed curves corresponds to form factors (A.3), (A.5). The curve $w^{(L.M.)}(x_\pi)$ correspond to the contribution of large masses ($m_R^2 > 2$ GeV^2) calculated with the form factor of ref. 10, where the triple-pomeron region of inclusive nucleon spectra has been described.

The quantities n_R and X_R for R = N, Δ and $m_R^2 > 2$ GeV^2 and $n_{\pi/N}=\sum_R n_R$; $X_{\pi/N}=\sum_R n_R X_R/n_{\pi/N}$ which follows from these distributions are given in Table I.

It is easy to see that in the framework of the π-meson exchange model the inelastic cross section of NN interaction is connected asymptotically to the total πN cross section by the relation

$$\sigma_{NN}^{inel} \simeq n_{\pi/N}\,\sigma_{\pi N}^{tot} \qquad (27)$$

For $n_{\pi/N} \simeq 1.4$ and $\sigma_{\pi N}^{tot} \simeq 24$ mb this relation gives $\sigma_{NN}^{inel} \simeq 32$ mb which is in an agreement with the experimental value.

At present an information on the π-meson structure function follows mainly from the data on the muon pairs production in πN-collisions [5,6]. The experimental data of Refs. [5] and [6] differ in normalization, in particular the quark distribution in pion were extracted from the data of Ref. [6] by the Drell-Yan formula with the use of normalization factor $K \simeq 2{,}3$. The factor of the same magnitude is needed in order to describe by the Drell-Yan formula the data of Ref. [6] for proton beam.

The data on π-meson structure function of ref. [5] and the results of ref. [6] obtained with the normalization factor $K \simeq 2{,}3$ do not contradict each other and are shown in Fig. 6. We have used the following parametrization of this function

$$F^{\pi}(x) = x q^{\pi}(x) = 0.5\sqrt{x}(1-x) + 0.2(1-x)^3 \qquad (28)$$

where the first term corresponds to the valence quark distribution in pion and the second one - to the sea contribution. The distribution (28) gives for the mean fraction of momentum carried by quarks the value $X_{q/\pi} = X_{\bar{q}/\pi} \simeq 19\%$, i.e. gluons carry about 60% of the total momentum. The curve in Fig. 6 corresponds to the parameterization given by Eq.(28).

The antiquark distribution in nucleon $x\bar{q}^N(x)$ calculated using Eqs. (8), (A.3), (A.4), (28) is shown in Fig. 7. To illustrate the uncertainty of the theoretical calculation due to parametrization of form factors we give predictions for two extreme sets of parameters (shaded area in fig. 7) both of which lead to a reasonable description of the experimental data on Drell-Yan process and inclusive N and Δ-production in the framework of the π-exchange model.

The large mass contribution is shown by the dashed curve. It is important at very small $x \lesssim 0.05$.

The antiquark distribution in nucleon obtained from the experimental data [8] on the deep inelastic neutrino scattering is shown in the same figure.

The theoretical calculations agreee with the experimental data. They give for the mean fraction of energy carried by antiquarks in nucleon the value $X_{\bar{q}/N} \simeq 7\text{-}8\%$. The experimental value of this quantity given by the data of different groups in different energy regions is about 3-8% (see ref. [11]).

5. Conclusions

In this work we have investigated the first stage of multiperipheral fluctuation - a single emission of "effective" π -meson. In principle, in this approach the whole peripheral structure of the fast hadron (of Amati-Fubini-Stanghellini multiperipheral ladder-type) can be calculated. This distribution, formed at large distances, can be used as the basis (initial condition) for QCD calculations at short distances because hard processes allow one to investigate the short distances hadronic structure. Thus this approach gives the possibility to obtain initial conditions for the evolution equations of quark-gluon distributions in QCD [9].

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Appendix

Here we give expressions for the functions $g_R(t)$ and $G_R(t)$, $R=N,\Delta$. Functions $g_R^2(t)$ after taking spin average have the form

$$g_N^2(t) = -g_{\pi NN}^2 \cdot t \quad ,$$
$$g_\Delta^2(t) = g_{\pi N\Delta}^2 \left[(M_\Delta - m)^2 - t\right]\left[(M_\Delta + m)^2 - t\right]^2 / 6M_\Delta^2 \qquad (A.1)$$

where

$$g_{\pi^0 pp}^2/4\pi = 14.6$$
$$g_{\pi^+ p\Delta^{++}}^2/4\pi = 19 \ \text{GeV}^{-2} \qquad (A.2)$$

Functions $G_R(t)$, which include the π-meson propagator and the dependence of πNR-vertices and πN-cross sections on the square of the vitrual pion mass, have the following form

$$G_R(t) = \exp\left[(R_{1R}^2 + \alpha_\pi' \ln s/\tilde{s})(t-\mu^2)\right] \times$$
$$\times \begin{cases} \pi\alpha_\pi'/2\sin\left[\pi\alpha_\pi'(t-\mu^2)/2\right] & , \ |t| < |T_R| \\ \exp\left[R_{2R}^2(t-T_R)\right] \cdot \pi\alpha_\pi'/2\sin\left[\pi\alpha_\pi'(T_R-\mu^2)/2\right] , & |t| > |T_R| \end{cases} \qquad (A.3)$$

The values of parameters form ref. [1], used in our calculations are listed below

$$R^2_{1N}=0.3\,\mathrm{GeV}^{-2},\ R^2_{2N}=0.4\,\mathrm{GeV}^{-2},\ T_N=-0.5\,\mathrm{GeV}^2 \qquad (A.4a)$$

$$R^2_{1\Delta}=0.2\,\mathrm{GeV}^{-2},\ R^2_{2\Delta}=0.7\,\mathrm{GeV}^{-2},\ T_\Delta=-1\,\mathrm{GeV}^2 \qquad (A.4b)$$

$$\alpha'_\pi=1\,\mathrm{GeV}^{-2}.$$

We also use another set of parameters

$$R^2_{1N}=0.3\,\mathrm{GeV}^{-2},\ R^2_{2N}=0.4\,\mathrm{GeV}^{-2},\ T_N=-0.8\,\mathrm{GeV}^2 \qquad (A.5a)$$

$$R^2_{1\Delta}=0.5\,\mathrm{GeV}^{-2},\ R^2_{2\Delta}=0.74\,\mathrm{GeV}^{-2},\ T_\Delta=-0.7\,\mathrm{GeV}^2 \qquad (A.5b)$$

Let us note that both sets of parameters (A.4) and (A.5) lead to the quantitative description (within experimental errors) of Drell-Yan process and processes of inclusive N and Δ-production, described by the diagrams, which differ from the diagram of fig. 3 by the substitution of the cross section of the reaction $\pi N \to llX$ by the total cross section of πN-interaction.

TABLE I

	R / Variant	N	Δ	L.M. ($m_R^2 > 2\,GeV^2$)	Total
n	I	0.58	0.53	0.27	1.38
	II	0.47	0.57	0.26	1.31
X	I	0.25	0.18	0.015	0.18
	II	0.19	0.20	0.017	0.21

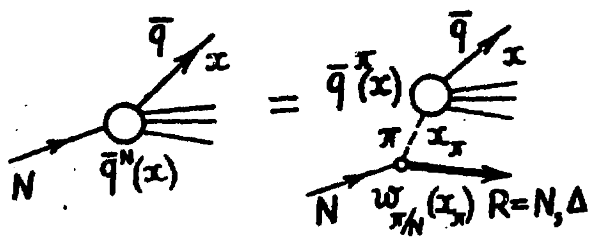

Fig. 1. The diagram illustrating the connection between the antiquark distributions in nucleon and pion in the framework of π-exchange model

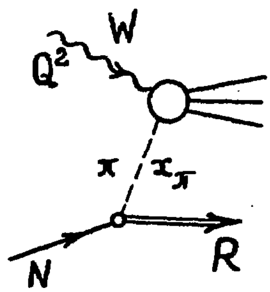

Fig. 2. The diagram of π-meson exchange, which relates the deep inelastic scattering of leptons on pion and nucleon

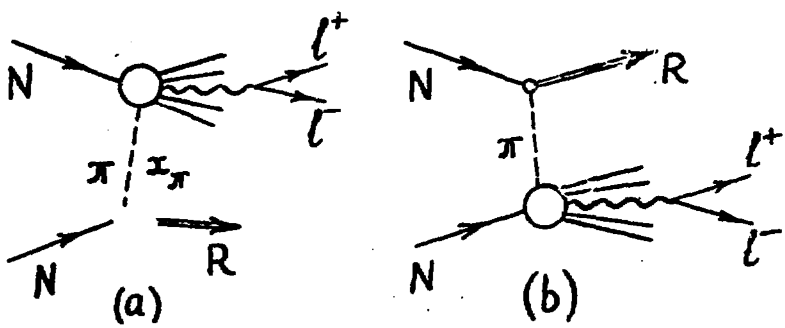

Fig. 3. The diagram of π-meson exchange, which relates the processes of massive pair production in NN and πN collisions

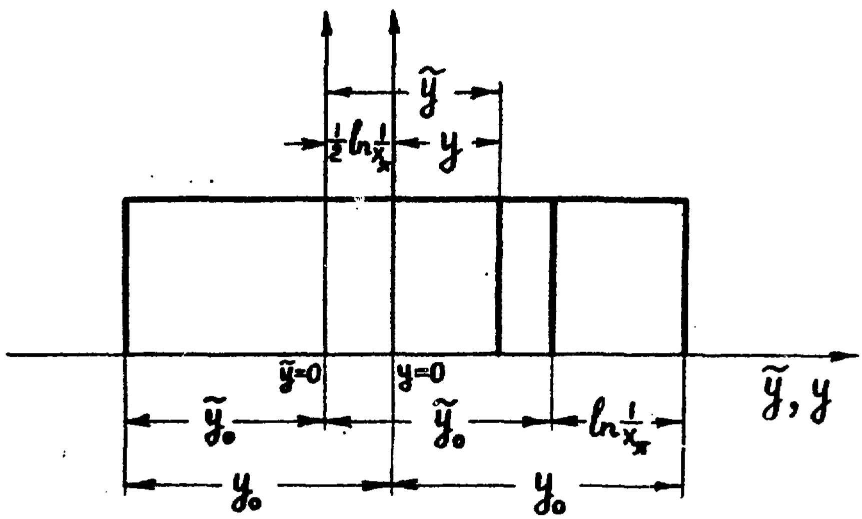

Fig. 4. Relation between the kinematical boundaries in the rapidity variables y and $\tilde{y}$.

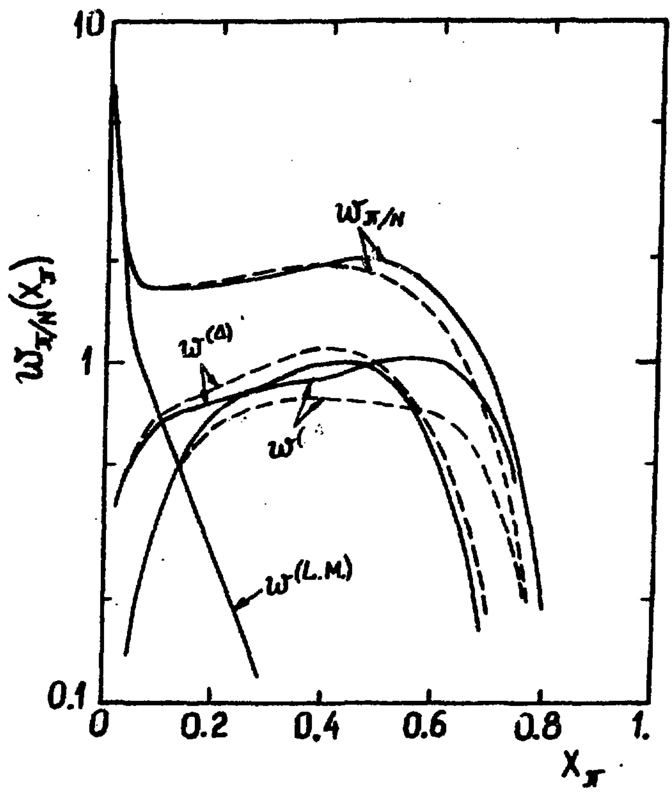

Fig. 5. The distributions $w^{(N)}(X_\pi)$, $w^{(\Delta)}(X_\pi)$, $w^{(L.M.)}(X_\pi)$ and $w_{\pi/N}(X_\pi)$

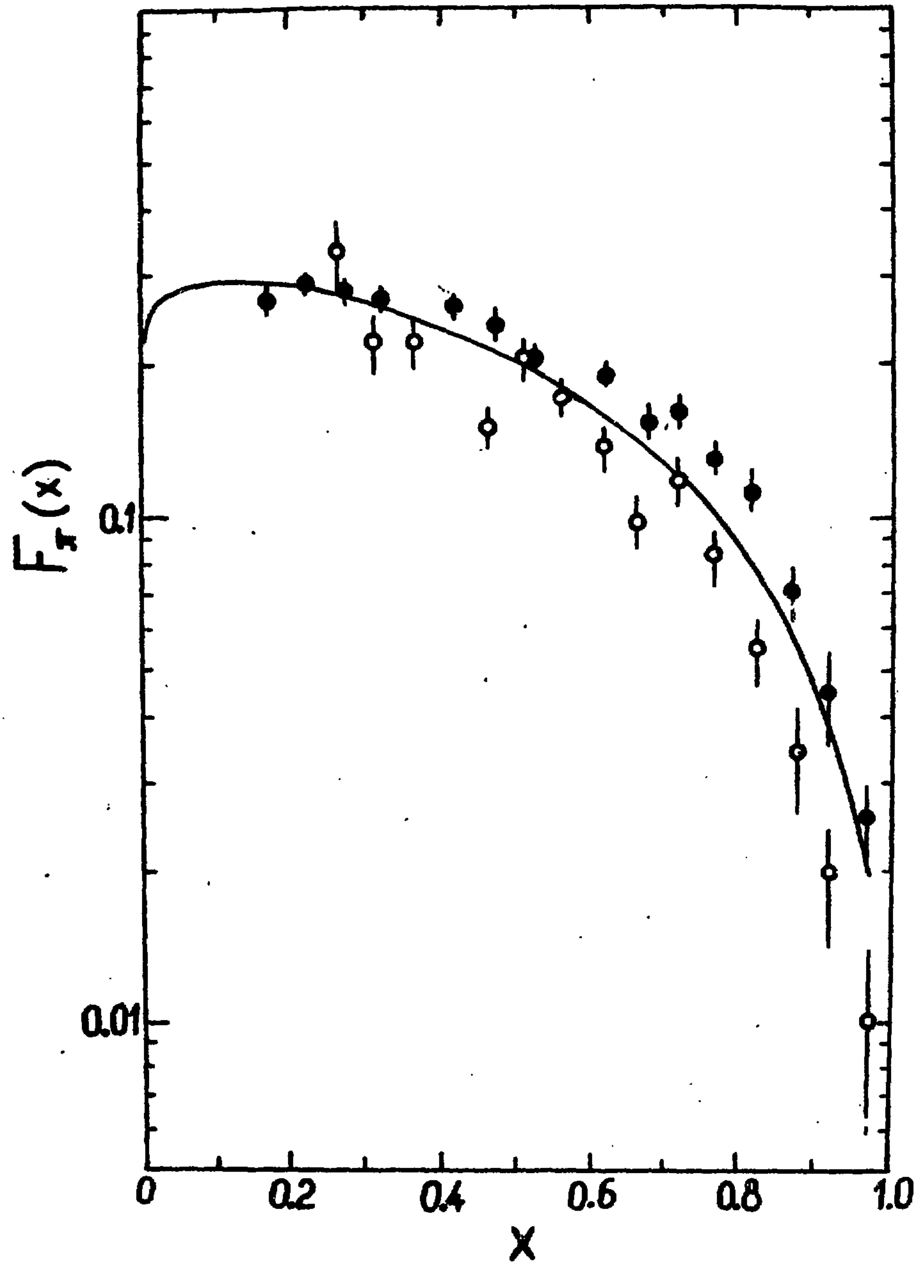

Fig. 6. Structure function of $q(\bar{q})$ in π-meson from ref. [5,6] .

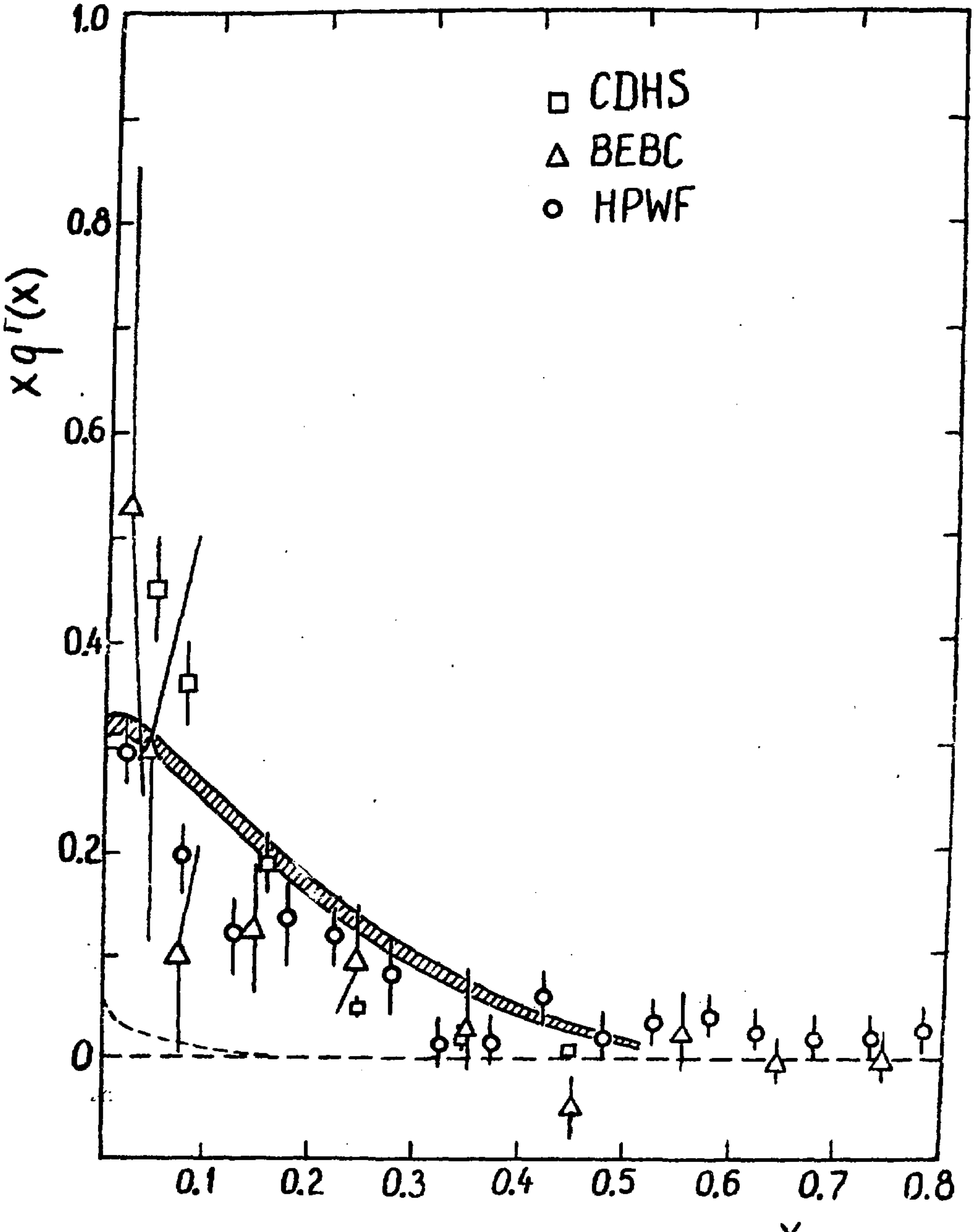

Fig. 7. Comparison between the experimental data [8] and the theoretical calculations for the $\bar{q}$ distributions in nucleon.

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