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INCLUSIVE SPECTRA OF PSEUDOSCALAR η, η', i(1440) MESONS WITH ACCOUNT OF QUARC-GLUON MIXING

ЦНИИатоминформ

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ԲԱԴԱԼՅԱՆ Ռ.Գ., ՆԱԶԱՐՅԱՆ Ա.Է.

η և η', ι/1440/ ԹՅՈՒՐ-ՍԿԱԼՅԱՐ ՄԵԶՈՆՆԵՐԻ ԻՆԿԼՅՈՒԶԻՎ ՍՊԵԿՏՐԵՐԸ՝ ՆՐԱՆՑՈՒՄ ՔՎԱՐԿ-ԳԼՅՈՒՈՆԱՅԻՆ ԽԱՌՆՈՒՄՈՎ

η, η', ι/1440/ մեզոններում քվարկ-գլյուոնային խառնումով Բազմապարտոնային վերամիավորման մոդելի շրջանակներում պրոտոնի հա-մեծավորման ոլորտում ստացվել են հադրոն-հադրոնային փոխազդեցություններում այդ մասնիկների ինկլյուզիվ սպեկտրերը: Ցույց է տրված գլյուոնային միճակի փոխարկման սկզբնական պրոտոնի գլյուոնային ծովի որոշման հնարավորությունը՝ օգտվելով այդ մեզոնների ինկլյուզիվ սպեկտրերից:

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Within the [illegible] account of quark gluon mixing in η, η', ι([illegible]) [illegible] the inclusive spectra of the latters in hadron-hadron interactions in the proton fragmentation region are obtained. A possibility to determine by inclusive spectra of these mesons a portion of the initial proton gluonic sea fragmentizing to gluonic state is pointed out.

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ИНКЛЮЗИВНЫЕ СПЕКТРЫ ПСЕВДОСКАЛЯРНЫХ МЕЗОНОВ η , η' , ι(1440) С УЧЕТОМ КВАРК-ГЛЮОННОГО СМЕШИВАНИЯ В НИХ

В рамках многопартонной рекомбинационной модели с учетом кварк-глюонного смешивания в η , η' , ι(1440) мезонах получены инклюзивные спектры этих частиц в адрон-адронных взаимодействиях в области фрагментации протона. Указана возможность определения доли глюонного моря начального протона, фрагментирующей в глюонное состояние, по инклюзивным спектрам этих мезонов.

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The inclusive spectra of fast hadrons with small transverse momenta in the fragmentation regions of interacting hadrons are of great interest in connection with a test of various mechanisms of formation of such particles. At present, the model approach to description of the processes with small P_T is inevitable, since the problem of soft hadronization and decolorization of quark-gluon systems is beyond solution within the quantum chromodynamics (QCD).

In various recombination models (RM) [1-3], a relationship is established between the distribution functions of valent quarks in initial hadron sea partons and inclusive cross sections of final hadron production in fragmentation regions of initial particles. According to these RM, in the production of final hadron, there participate a limited number of quarks (antiquarks) of initial hadron (two quarks in the case of meson production and three ones - in (anti-)baryon production), whose longitudinal momenta determine that of final hadron.

Within the multiparton recombination model (MRM) [4,5], there is considered a more general case of transition from initial hadron to final one of arbitrary number of partons, whose summary longitudinal momentum determines longitudinal momentum of final hadron. The final hadron longitudinal momentum introduced by the initial hadron sea partons is determined by the value of parameter W which characterizes a probability for the initial hadron sea parton to enter the final hadron sea content. In the mentioned RM, parameter W is assumed zero a priori. However, as shown in Refs.[4-6], the values of W substantially differ from zero for the processes with $N_V = 2$ (processes with diquark; $W \approx 2/3$) and $N_V = 3$ (diffraction-type processes; $W \approx 1$), where N_V is the number of mutual valent quarks of initial and final hadrons. MRM allows one to determine inclusive cross sections of final hadron production at known distributions of valent quarks and sea partons in initial and final hadrons. For the distribution of valent u- and d-quarks and sea partons in proton, within the Kuti-Weisskopf model [7], there are obtained [6] the following expressions:

$$x u(x) = 2x^{\beta_u}(1-x)^{-1+\gamma+\beta_u+\beta_d} B_2^{ud}(1;1-x), \qquad (1a)$$

$$x d(x) = x^{\beta_d}(1-x)^{\gamma+2\beta_u} B_2^{uu}(1;1-x), \qquad (1b)$$

$$x a_s(x) = g_a(1-x)^{-1+K_a+\gamma+2\beta_u+\beta_d} B_3(1;1-x), \qquad (1c)$$

where x is the Feynman variable (the parton momentum portion in the proton momentum units), $a = u, \bar{u}, d, \bar{d}, s, \bar{s}, G$ - denotes a type of sea parton,

$$\begin{gathered} \beta_u = \beta_d = 0{,}5; \quad \lambda = 2g_s/(g_u+g_d) = 1/8 . \\ g_u = g_{\bar{u}} = g_d = g_{\bar{d}} = 0{,}12; \quad g_s = g_{\bar{s}} = 0{,}015; \quad g_G = 3 .. \\ K_u = K_{\bar{u}} = K_d = K_{\bar{d}} = K_s = K_{\bar{s}} = 1; \quad K_G = 3 . \quad \gamma = \sum_a g_a = 3{,}51 . \end{gathered} \qquad (2)$$

The functions $B_2^{ud(uu)}(1;x)$ and $B_3(1;x)$ are determined in Refs.[4-6] and presented in Fig.1. They are well approximated by the function

$A\exp\{-Bx\}$. The values of parameters A , B are listed in Table 1. The distributions of valent quarks and sea partons in proton are given in Fig.2. In the framework of MRM the invariant inclusive cross section $f(x) = \frac{1}{\sigma_{in}} \int \frac{E}{P_{max}} \frac{d^2\sigma}{dx\, dP_T^2} dP_T^2$ of meson production $M=(q_1 \bar{q}_2)$ in the proton fragmentation region is determined [6] by the expression:

$$f(x) = \int [F_{[illegible]}(x_1, x_2) + F_{ss}(x_1, x_2)] R_M\left(\frac{x_1}{x}, \frac{x_2}{x}\right) \delta\left(1 - \frac{x_1}{x} - \frac{x_2}{x}\right) dx_1 dx_2 \qquad (3)$$

[illegible] brackets corresponds to the fragmentation process [illegible] initial [illegible]

[illegible]

[illegible]

[illegible]

quarks [illegible] [6].

a) [illegible] quark (longitudinal momentum x_1 , $x = x_1 + x_2$)

$$[illegible] \qquad (4a)$$

b) [illegible] quark (longitudinal momentum x_1 , $x = x_1 + x_2$)

$$F_{[illegible]}(x_1, x_2) = g_{[illegible]}(1-x)^{-1+\gamma+2\beta_u} x_1^{-1+\beta_u}(1-x_1) x_2^{-1}(1-x_2)^{K_a} B_{[illegible]}^{uu}(1; 1-x) \qquad (4b)$$

The function $F_{ss}(x_1, x_2)$ and $R_M(z_1, z_2)$ are taken from Ref. [illegible] and have the forms.

$$F_{ss}(x_1, x_2) = g_a g_{\bar{s}} (1-x)^{-1+\gamma+2\beta_{[illegible]}+\beta_d} x_1^{-1}(1-x_1)^{K_a} x_2^{-1}(1-x_2)^{K_{\bar{s}}} B_3(1; 1-x), \qquad (5)$$

$$R_M(z_1, z_2) = B(\alpha_{q_1}+1, \alpha_{\bar{q}_2}+1)\, z_1^{1+\alpha_{q_1}} z_2^{1+\alpha_{\bar{q}_2}} , \qquad (6)$$

where $a, b = u, \bar{u}, d, \bar{d}, s, \bar{s}, G$; $\alpha_q = -1 + \gamma_M/2 + \beta_M$; $\gamma_M = 1,6$.

$B(x, y)$ is the Euler function.

Within QCD the gluons while interacting to each other are expected to form bound states - glueballs, which in the general case can be observed as a mixture with neutral isoscalar mesons composed of quark-antiquark pairs. In particular, both existing candidates for gluonic bound states ι(1440): ($J^{PC} = 0^{-+}$) [8], θ (1690); ($J^{PC} = 2^{++}$) [9] may have quark-antiquark admixture. This can be checked by various tools [10-12]. The analysis [12] of the available experimental data on binary reactions and decays containing η , η' , ι(1440) mesons points out that there takes place quark-gluon mixing in these mesons (the standard singlet-octet mixing does not explain the experimental materials available).

In the quark-gluon mixing model the ideal basis contains the state vectors of normal $|N\rangle = \frac{1}{\sqrt{2}}|u\bar{u} + d\bar{d}\rangle$ and strange $|S\rangle = |s\bar{s}\rangle$ quarkonia and pure gluonium $|G\rangle$.

The physical states $|\Psi_K\rangle (K = \eta, \eta', \iota)$ are their linear combination:

$$|\Psi_K\rangle = X_K|N\rangle + y_K|S\rangle + Z_K|G\rangle \tag{7}$$

Parameters X_K, y_K, Z_K are functions of the free parameter of theory. Their values taken from Ref.[12] are listed in Table 2. They determine a relative contribution of normal and strange quarkonia and gluonium to η , η' , ι (1440) mesons. With respect to the quark-gluon content of these mesons, their inclusive spectra are just determined within MRM.

The invariant inclusive cross section $f(x)$ of the proton fragmentizing to the $|N\rangle, |S\rangle, |G\rangle$ states within MRM is determined for the values of parameters (2) by the following expressions:

$$f_N(x) = \frac{B(\alpha_N+\beta_N+1, \alpha_N+1)}{B(\alpha_N+1, \alpha_N+1)} \Big[g_{\bar u} B_2^{ud}(1;1-x)\Big(1 - \frac{2(\alpha_N+1)}{4\alpha_N+5} x\Big) +$$

$$\cdot \frac{g_{\bar d}}{2} B_2^{uu}(1;1-x)\Big(1-x+\frac{2(\alpha_N+1)(2\alpha_N+3)}{(4\alpha_N+5)(4\alpha_N+7)} x^2\Big)\Big] \cdot \qquad (8a)$$

$$\cdot x^{\beta_N}(1-x)^{\gamma} + g_N^2 B_3(1;1-x)(1-x)^{\gamma+\beta_N}\Big(1-x+\frac{\alpha_N+1}{2(2\alpha_N+3)} x^2\Big),$$

$$f_S(x) = g_S^2 B_3(1;1-x)(1-x)^{\gamma+\beta_N}\Big(1-x+\frac{\alpha_S+1}{2(2\alpha_S+3)} x^2\Big), \qquad (8b)$$

$$f_G(x) = \frac{(\Delta g_G)^2}{2!} B_3(1;1-x)(1-x)^{\gamma+\beta_N}\Big[1-3x+\frac{3(5\alpha_G+7)}{2(2\alpha_G+3)} x^2 -$$

$$- \frac{5\alpha_G+6}{2\alpha_G+3} x^3 + \frac{3(\alpha_G+1)(5\alpha_G+12)}{4(2\alpha_G+3)(2\alpha_G+5)} x^4 - \qquad (8c)$$

$$- \frac{3(\alpha_G+1)(\alpha_G+12)}{4(2\alpha_G+3)(2\alpha_G+5)} x^5 + \frac{(\alpha_G+1)(\alpha_G+2)(\alpha_G+3)}{8(2\alpha_G+3)(2\alpha_G+5)(2\alpha_G+7)} x^6\Big].$$

Here $\alpha_{N(S,G)} = -1+\gamma_M/2+\beta_{N(S,G)}$; $\gamma_M = 1{,}6$, $\beta_N = 0{,}5$, $\beta_S = 1$. and $0 \leqslant \beta_G \leqslant 1$ (the inclusive spectrum $f_G(x)$ weakly depends on the value of quantity β_G).

In the processes of proton fragmentation to gluonium $|G>$, a contribution of only a certain portion of the initial proton gluonic sea is possible. This circumstance is reflected in expression (8c) by the insertion of parameter Δ which characterizes the degree of participation of the initial proton gluonic sea in formation of gluonic state $|G>$ in the fragmentation region of initial proton. The knowledge of invariant inclusive cross sections $f_{N(S,G)}(x)$ and mixing parameters of nonstrange, strange and gluonic components x_K , y_K , z_K ($K = \eta$, η' , ι (1440)) enables one to determine inclusive cross sections of η , η', and $\iota(1440)$ mesons in the proton fragmentation region:

$$f_K(x) = x_K^2 f_N(x) + y_K^2 f_S(x) + z_K^2 f_G(x) \quad (9)$$

The inclusive spectra of proton fragmentation in η , η' and $\iota(1440)$ for the values Δ = 0.1, 0.3 and 1 are presented in Fig.3. In order to determine the values of parameter Δ by spectra of fragmentation $p \to \eta$, one should have experimental points in the region of small x ($x \leq 0.4$). Unfortunately, experimental data on inclusive spectra of η -mesons in the proton fragmentation region are rather poor. The data on η -meson spectra in the proton fragmentation region in $\pi^+ p$ interactions at initial momentum of 16 GeV/c [13] do not enable one to draw certain conclusions about participation of the initial proton gluonic sea in the formation of gluonic component $|G>$ (Fig.4). A more reliable information on the value of parameter Δ can be provided by experimental data on inclusive spectra of η', ι mesons in the proton fragmentation region in pp ($p\bar{p}$), $\pi^+ p$, $K^{\pm} p$ interactions at high energies.

Table 1

	$B_2^{uu}(1;x)$	$B_2^{ud}(1;x)$	$B_3(1;x)$
A	8.736	8.736	7.478
B	2.109	2.297	2.012

Table 2

	η	η	$\iota(1440)$
x	0.724	-0.588	-0.355
y	-0.685	-0.682	-0.261
z	-0.0830	0.436	-0.898

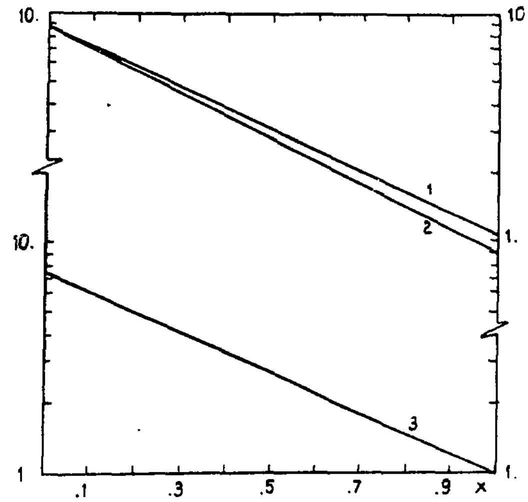

Fig.1. Functions $B_2^{uu}(1;x)$ - curve 1, $B_2^{ud}(1;x)$ - curve 2, and $B_3(1;x)$ - curve 3.

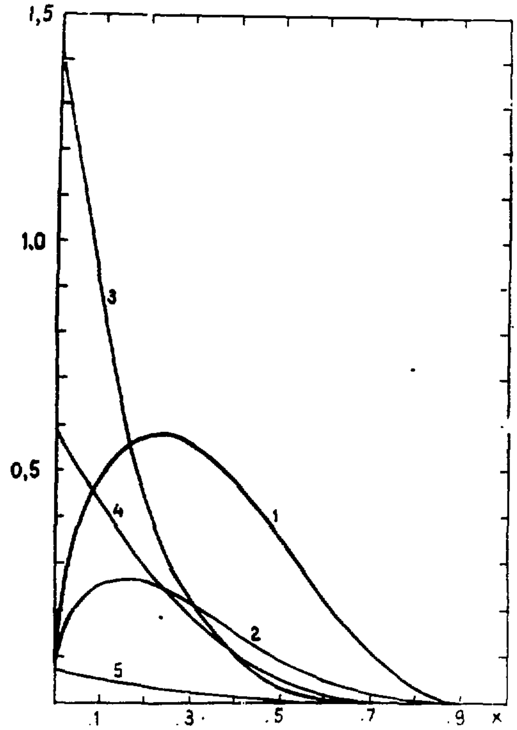

Fig.2. Distributions of valent quarks $xu(x)$, $xd(x)$ and sea parcons $xq_s(x)$ in the proton. Curve 1 - valent u-quark, 2 - valent d-quark, 3 - gluons (x0.5), 4 - sea u, d quarks and antiquarks (x 5), 5 - S quark and antiquark (x 5).

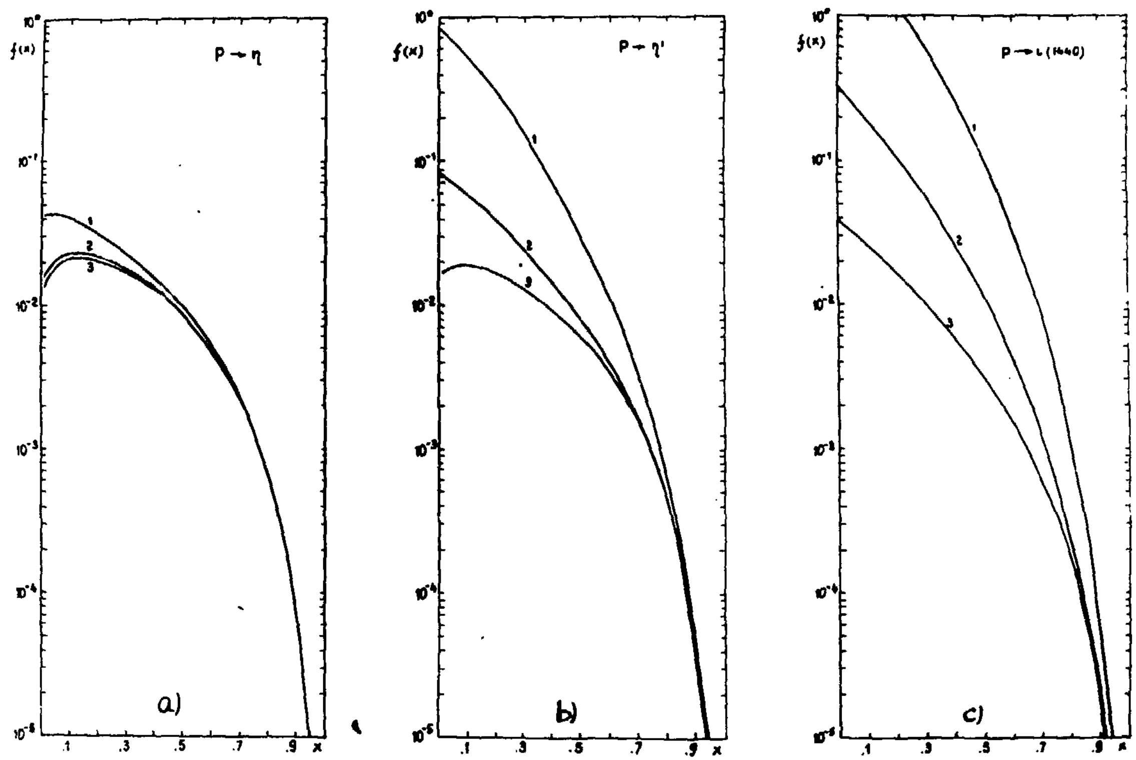

Fig.3. Invariant inclusive spectra of $\eta(a)$, $\eta'(b)$, $\iota(c)$ mesons in the proton fragmentation region: curve 1 - $\Delta = 1$, 2 - $\Delta = 0.3$, 3 - $\Delta = 0.1$.

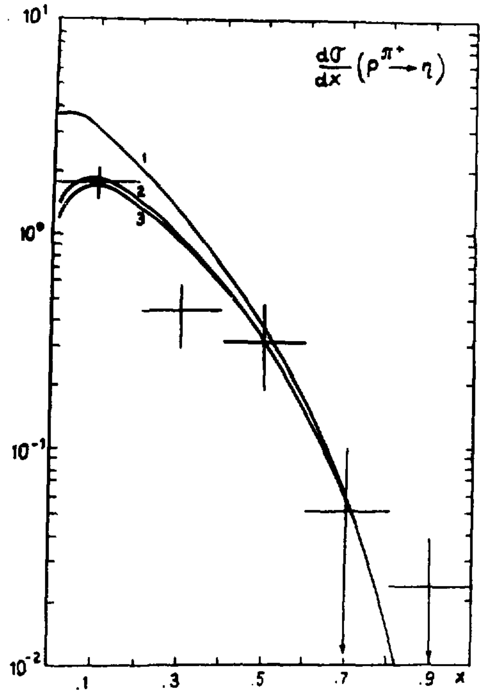

Fig.4. Inclusive spectrum of η -meson in the proton fragmentation region in $\pi^+ p$ interactions at 16 GeV/c: curve 1 at $\Delta = 1$, 2 - $\Delta = 0.3$, 3 - $\Delta = 0.1$. Experimental points are taken from Ref.[13] , with the corresponding corrections to the normalization.

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