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POTENTIAL WITH A DIMENSIONAL PARAMETER IN THE MODEL OF "HARD COLLISION"

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Потенциал с размерным параметром в модели жестких соударений

Рассмотрено рассеяние кварков на эффективном потенциале, содержащем размерный параметр. Показано, что полученное с использованием предположения о факторизуемости кварковых амплитуд сечение рассеяния кварка на кварке хорошо описывает данные по реакции $pp \to \pi^0 X$.

Работа выполнена в Лаборатории теоретической физики, ОИЯИ.

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Potential with a Dimensional Parameter in the Model of "Hard Collision"

The quark scattering on effective potential containing the dimensional parameter is considered. It is shown that the data on reaction $pp \to \pi^0 X$ are well described within the assumption of factorizability of the quark amplitudes.

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

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Recently the cross section of inclusive reaction $pp \to \pi^0 X$ ($\Theta_{c.m.} = 90°$) has been measured in the region of "very large" meson momenta: $p_\perp \leq 15$ GeV/c /1/. It was established that the cross section decreases as $p_\perp^{-8}$ /2/ for $p_\perp \sim 2.4 \div 6.0$ GeV/c while for $p_\perp \sim 10 \div 15$ GeV/c, $p_\perp^{-6,6}$ /3/.

In this article the quark scattering in the subprocess of "hard collision" is a purpose of such a potential, that allows us to describe the cross section of reaction $pp \to \pi^0 X$ in a wide region of pion momenta: $p_\perp \sim 2,46 \div 15$ GeV/c.

Within the dynamical model of factorizing quarks (DMFQ) /4/ the potential is setting on the relativistic configurational representation (RCR). The transition from the momentum representation to the RCR is realized through the expansion over the functions /5/ ($\hbar = c = 1$):

$$\xi(\vec{p}, \vec{r}) = \left(\frac{p_0 - \vec{p}\vec{n}}{m} \right)^{-1-irm} \qquad (1)$$

(m is the quark mass). These functions (1) realize the unitary infinite-dimensional irredusible representatinns of the Lorentz group. The amplitude of scattering of a quark in the Born approximation is given as follows /6/:

$$g_i(\theta) = 4\pi \int_0 \frac{\sin r m y_i}{r m y_i} V_{eff}(r)\, r^2 dr, \qquad (2)$$

where $y_i = \mathrm{Arch}\,(1 - t_i/2m^2)$, t_i is the momentum transferred to one quark. Earlier the potential was taken in the form: $V_{eff}(r) = \delta(r)/4\pi r^2$ brought to $g_i(\theta) = y_i/\mathrm{sh}\, y_i$. However, such an amplitude allowed us to describe the experimental data over the region $p_\perp \sim 2.4 \div 7$ GeV/c /7/ only. To take into account the previously mentioned change of regime $p_\perp^{-8} \to p_\perp^{-6,6}$, we shall introduce into the potential the length of a dimensional parameter ρ:

$$V_{eff}(r) = \delta(r + i\rho)/4\pi r^2. \qquad (3)$$

Inserting (3) into (2) we obtain:

$$g_i(\theta) = -\frac{\mathrm{sh}\, \rho m y_i}{\rho m y_i}. \qquad (4)$$

In the framework of DMFQ we found the following expression for the quark-quark cross section:

$$\frac{d\sigma}{dt} \sim \frac{A}{s^2}\left(\frac{\mathrm{sh}\,\rho m y_i}{\rho m y_i}\right)^4 \xrightarrow[-t\to\infty]{} \frac{A}{s^2}\left(\frac{|t|}{m^2}\right)^{-N_{eff}}, \qquad (5)$$

where $N_{eff} = 4(1 - \rho m)$.

Formula /4/ in the limit $\rho m y_i \ll 1$ reduces to the one obtained in /4/. When ρ is equal to the Compton wave length ($\rho = m^{-1}$) of quark (CWL), then $d\sigma/dt \sim s^{-2}$ according to the quark counting rule predictions /8/.

Farther we use expression(5) for the quark-quark scattering cross section to calculate the cross section of reaction $pp \to \pi^\circ X$ by the formula of the model of "hard collisions" /9/:

$$E\frac{d^3\sigma}{dp^3}(AB \to hX) = \int dx_a\, dx_b \sum_{a,b} G_A^a(x_a)\, G_B^b(x_b)\, D_c^h(z_c) \frac{1}{z_c \pi} \frac{d\sigma}{dt}, \qquad (6)$$

where $G_A^a(x)$ is the distribution function for quarks in hadron A and $D_c^h(z)$ is the function of fragmentation of quark c into hadron h. We choose the Q^2-independent functions $G_A^a(x)$ and $D_c^h(z)$ /10/. For quark masses we take typical value $m_u = m_d = 0.33$ GeV, and the contribution from other quarks, like in /10/ was not taken into account.

The results of fitting the experimental data by formulae (5) and (6) are given in the Table and in the Figure and display a good description. We obtain the value of ρ, which is three times as large as the CWL of quark and approximately equal to the CWL of proton $\rho \approx m_p^{-1}$.

The existence of peculiarity in the potential of $N\bar{N}$-interaction at such distances was pointed out in /11/.

Thus, the presence in the potential of quark-quark scattering of two dimensional parameters m and ρ allow us to make a good description of data on reaction $pp \to \pi^\circ X$ ($\theta_{c.m.} = 90°$) in the region of an intermediate value of a scaling variable $x = 2p_\perp/\sqrt{s} \lesssim 0.5$.

The authors express their sincere gratitude to S.P.Kuleshov for useful discussions.

Table

$\sqrt{s}$ (GeV)	$10^3 \times A$ [$\mu b\, GeV^2$]	ρ [GeV^{-1}]	$\chi^2_{d.f.}$
62.5	4.9 ± 0.7	0.97±0.02	130/44-2
52.7	7.0 ± 0.7	0.82±0.01	67/47-2

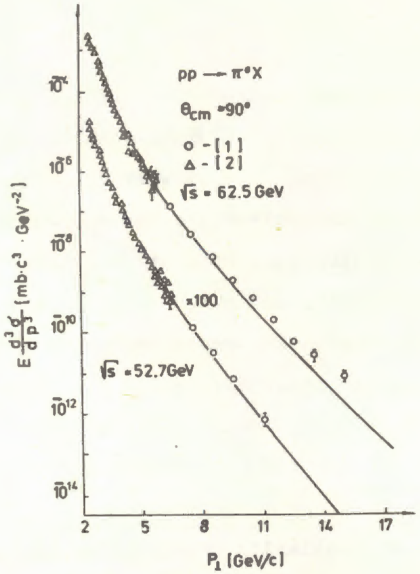

Fig. 1. Comparison of the DMFQ predictions with experimental data on $pp \to \pi^0 X$; $p_\perp \sim 2.4 - 6.5$ GeV/c /2/; $p_\perp \sim 6.5 \div 15$ GeV/c /1/.

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