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QUASIPOTENTIAL DESCRIPTION OF $\pi^{\pm}p$-SCATTERING AT LARGE ANGLES IN MODEL WITH DIMENSIONAL PARAMETER

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Квазипотенциальное описание $\pi^{\pm}p$-рассеяния на большие углы в модели с размерным параметром

Рассмотрено упругое $\pi^{\pm}p$-рассеяние в модели с размерным параметром, которым является масса кварка. Получено дифференциальное сечение, которое содержит логарифмическое отклонение от чисто степенного поведения и хорошо описывает экспериментальные данные. Сделаны предсказания для поведения сечения рассеяния в области больших импульсов налетающих пионов.

Работа выполнена в Лаборатории теоретической физики ОИЯИ.

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Kuleshov S.P., Sidorov A.V., Skachkov N.B. E2 - 12544

Quasipotential Description of $\pi^{\pm}p$-Scattering at Large Angles in Model with Dimensional Parameter

Elastic $\pi^{\pm}p$-scattering is considered in a model with the dimensional parameter, quark mass. The differential cross section is found. It contains the logarithmic deviation from the purely power behaviour and well describes experimental data. Predictions are made for the cross-section behaviour at large momenta of incident pions.

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

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The present experimental data indicate the power fall for the differential cross section of large-angle high-energy hadron-hadron scattering [1]

$$\frac{d\sigma}{dt} \sim \frac{1}{s^n} f\left(\frac{t}{s}\right), \quad s \to \infty, \quad \frac{t}{s} - \text{fixed} \tag{1}$$

(For instance, for elastic $\pi^{\pm}p$-scattering $n=8$ is observed). The power law (1) is predicted by the dimensional quark-counting rules [2]. The behaviour of the elastic-hadron-hadron-scattering cross section in a wide range of scattering angles can be well described within the Logunov-Tavkhelidze quasipotential approach [3,4].

In papers [5] based on that approach the elastic-hadron-scattering cross section was calculated for a large class of potentials. There also was determined the class of quasipotentials which give rise to the power behaviour (1) for elastic $\pi^{\pm}p$ and pp-scattering at large angles.

In this paper, we calculate the $\pi^{\pm}p$-scattering cross section by the method of ref. [5], however, the form of the quasipotential is defined by using the dynamical model of factorizing quarks [6]. The model assumes that the collision of two hadrons produced an effective potential which scatters quarks, constituents of hadrons. It is suggested that the hadron-scattering amplitude at angle θ (in the c.m.s.) is proportional to the product of scattering amplitudes of individual valence quarks on the effective potential

$$M_{ab \to ab} \sim \prod_i g_i^a(\theta) \prod_j g_j^b(\theta). \tag{2}$$

If one does not establish also the form of function g_i, one can calculate ratios of cross sections of different hadron-hadron reactions in the framework of the dynamical model of factorizing quarks [7].

Assuming, in addition, that range of quark interaction is of an order of the quark Compton wavelength, M_q^{-1} (M_q - is the effective mass of a valence quark), one may obtain the following expression for the amplitude of quark scattering on the effective potential [6].

$$g(t)=\frac{2M_q^2\ln[1-\frac{t_q}{2M_q^2}+\frac{1}{2M_q^2}\sqrt{t_q(t_q-4M_q^2)}]}{\sqrt{t_q(t_q-4M_q^2)}} . \tag{3}$$

t_q is the transfer momentum per one quark, $t_q = c_0 t$. Assuming the transfer momentum t to be equally distributed over the hadron valence quarks, we get $c_0 = \frac{1}{n^2}$, n being number of valence quarks in a hadron.

The considered model with the dimensional parameter well describes the proton elastic form factor, fulfils the Drell-Yan-West relation[6], and gives the quark-quark cross section $\frac{d\sigma}{dt}(qq\to qq)$ consistent with exp. data on inclusive reaction $pp\to\pi^{+}X$ for π^{+}- meson momenta from 2 GeV/c to 8 GeV/c [8].

As was mentioned, the power law (1) can be derived within the quasipotential approach. In this approach, the scattering amplitude $M(s;p',k')$ is determined from the quasipotential equation by the iteration method. For the differential cross section of $\pi^{\pm}$p-scattering one obtains the following expression [5]

$$\frac{d\sigma}{dt}=\frac{1+z}{s^2}|\phi_1(s,t)+\phi_2(s,t)|^2, \quad z=\cos\theta_{c.m.} . \tag{4}$$

Functions ϕ_1 and ϕ_2 are given in the form

$$\phi_1(s,t)=s\int_0^\infty dx\rho_1(s,x)e^{xt} ,$$

$$\phi_2(s,u)=s\int_0^\infty dx\,\rho_2(s,x)e^{xu} . \tag{5}$$

In the case of existence of the weak limit for densities ρ_1 and ρ_2,

$$\lim s^N\rho_1(s,x=\frac{\eta}{s})=\Psi_1(\eta),$$

$$\lim s^N\rho_2(s,x=\frac{\zeta}{s})=\Psi_2(\zeta), \tag{6}$$

$$0<\eta,\ \zeta<\infty, \quad N>0 ,$$

the scattering amplitude is a power function of s. If one takes into account the isospin structure of $\pi^{\pm}p$ - scattering, formula (4) becomes

$$\frac{d\sigma}{dt}(\pi^{\pm}p \to \pi^{\pm}p) = \frac{1-z}{s^2}\,|T^{\pm}(s,t,u)|^2 , \qquad (7)$$

where $T^{\pm}(s,t,u)$ is expressed through the scattering amplitudes in states with the total isospin of the system 1/2 and 3/2:

$$T^{+} = T_{3/2} \qquad T^{-} = \frac{1}{3}T_{3/2} + \frac{2}{3}T_{1/2} .$$

The functions $\rho_{1,2}$ in our paper were chosen in the form

$$\rho_1(s,t,x) = \frac{1}{s}\,g(s)^{\ell_1 - 1}\,x^{m_1}\exp(-x/g(t)),$$

$$\qquad (8)$$

$$\rho_2(s,u,x) = \frac{1}{s}\,g(s)^{\ell_2 - 1}\,x^{m_2}\exp(-x/g(u)),$$

where g is the amplitude of scattering of a quark on the above-mentioned effective potential.

For the function ρ (8) the amplitudes $T_{3/2}$ and $T_{1/2}$ are expressed in terms of the quark-scattering amplitudes on the effective potential as follows:

$$T_{3/2,1/2} = A_{3/2,1/2}\,g(s)^{\ell_1 - 1}\,g(t)^{m_1 + 1} + B_{3/2,1/2}\,g(s)^{\ell_2 - 1}\,g(u)^{m_2 + 1} . \qquad (9)$$

According to the hypothesis of factorizability of quark amplitudes we set: $\ell_1 + m_1 = 5$ and $\ell_2 + m_2 = 5$. This implies the $\pi^{\pm}p$-scattering amplitude is proportional to the product of five quark amplitudes.

Note that the function ρ we have chosen does not obey the condition (6), and the behaviour (7) is not purely power because of the logarithmic factors.

In this work we have compared the calculations by formulae (7) and (9) with experimental data on elastic $\pi^{\pm}p$ - scattering at large angles /10/. As a result, we calculate the parameters $A_{\frac{3}{2},\frac{1}{2}}, B_{\frac{3}{2},\frac{1}{2}}, \ell_1, \ell_2$ given in the Table Figures 1

Table

Parameters calculated by fitting the experimental data on large-angle elastic $\pi^{\pm}p$-scattering /10/ by formulae (7) and (9)

	A	B	ℓ_1	ℓ_2
$T_{3/2}$	4.6	1.5	2.04	1.0
$T_{1/2}$	23	0.76	3.68	1.0

and 2 show good agreement between the calculation by (7) and (9) and experimental data ($\frac{\chi^2}{\bar{\chi}^2}$ =1,5). The noncoincidence of curves for different values of p_L is due to the deviation from the purely power behaviour of the cross section. However, as is seen from graphs, this deviation is not large. Figure 3 displays the behaviour of the cross section of elastic $\pi^{\pm}p$-scattering for large p_L calculated by formula (7) with the parameters fitted from experiment. Generally speaking, instead of the parameter c_0 one should introduce two parameters, c_π and c_p, that determine portions of the momentum transfer per each quark in a meson and nucleon. For simplicity we put $c_\pi = c_p = c_0$ and assume c_0 for $\pi^{\pm}p$ scattering to be in the interval $\frac{1}{9} < c_0 < \frac{1}{4}$. From exp. (3) it is seen that parameters M_q and c_0 correlate strongly; the fit results in the relation $\frac{M_q^2}{c_0} \approx 0.7\,\mathrm{GeV}^2$, that gives for the quark mass the estimation: 0.28 GeV $< M_q <$ 0.42 GeV. This value coincides with that one obtained earlier in this model /6/ in analysing the electromagnetic form factors.

Thus, the use of the mass parameter allowed us to describe the deviation from the power behaviour for the $\pi^{\pm}p$-scattering cross section that indicates, the mass effects must be taken into account in the preasymptotic region.

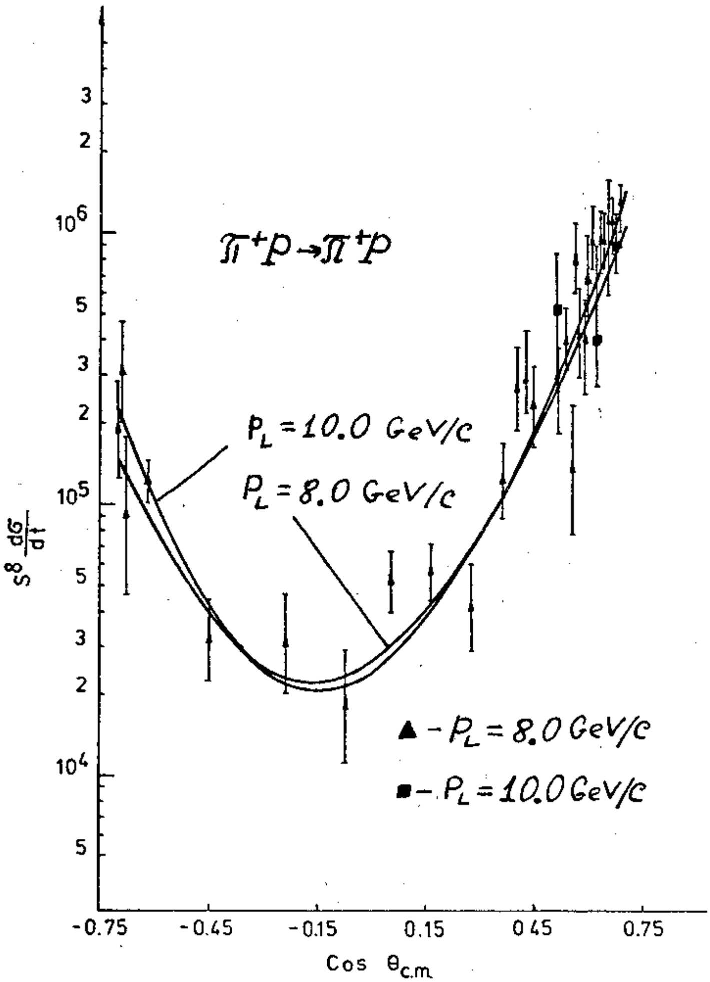

Fig.1. $s^8 \frac{d\sigma}{dt}$ for elastic reaction $\pi^+ p \to \pi^+ p$. p_L -momenta of incident pions.

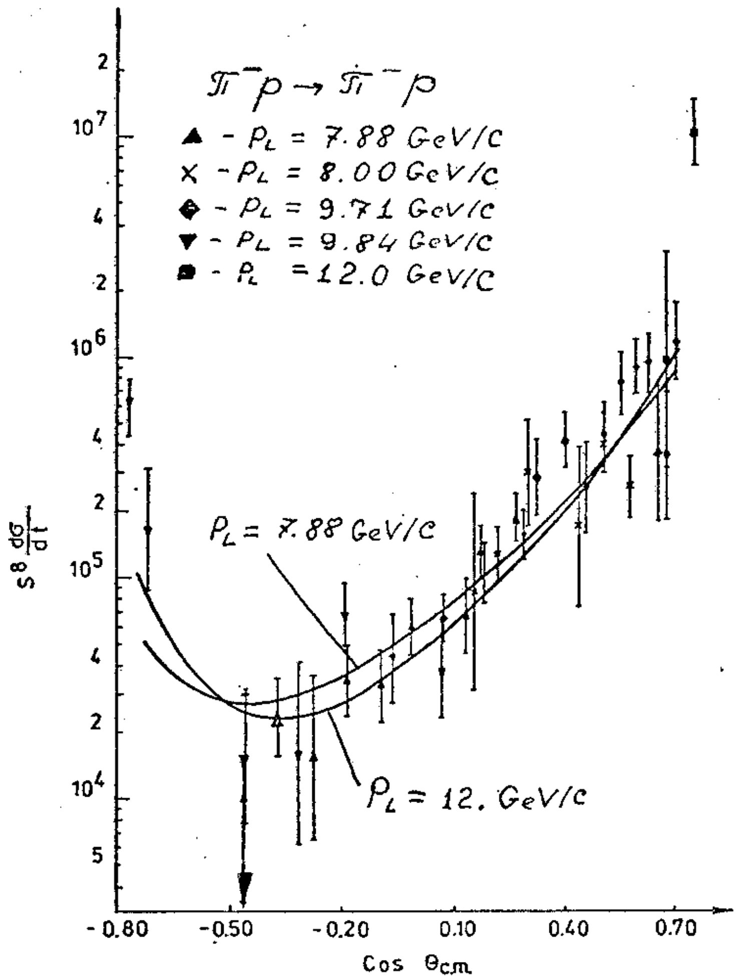

Fig.2. $s^8 \frac{d\sigma}{dt}$ for $\pi^- p \to \pi^- p$ for momenta of incident pions $-p_L$.

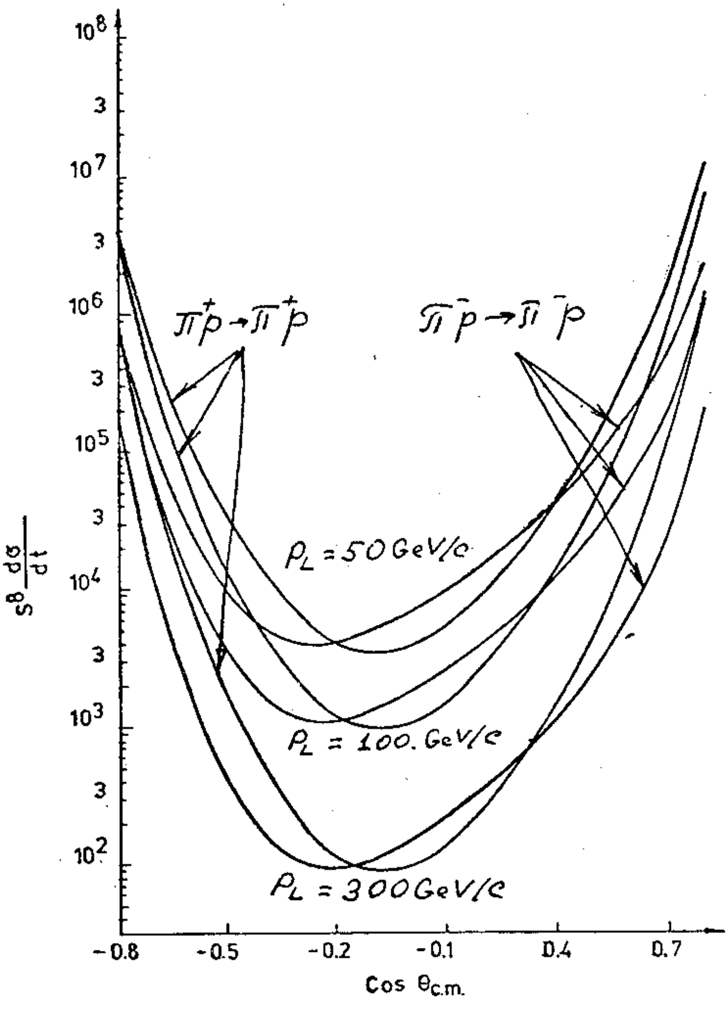

Fig.3. The behaviour of the cross section for $\pi^{\pm} p \to \pi^{\pm} p$ predicted in the range of large p_L .

REFERENCE

1. Barger V. Rapporteur's Talk at the XVII Int.Conf. on High Energy Phys., London, 1974.
2. Matveev V.A., Muradyn R.M., Tavkhelidze A.N. Lett.Nuovo Cim., 1973, 7, p. 719.
3. Logunov A.A., Tavkhelidze A.N. Nuovo Cim., 1963, 29, p. 380.
4. Kadyshevsky V.G., Tavkhelidze A.N. "Problems of Theoretical Physics", "Nauka", M., 1969, p. 261.
5. Goloskokov S.V. et al. JINR, P2-8211, P2-8337, Dubna, 1974; P2-9897, Dubna, 1976.
6. Pashkov A.F., Skachkov N.B., Solovtsov I.L. Sov.Pisma JETP, 1977, 25, p. 452; JINR, P2-10490,Dubna, 1977; P2-11211, Dubna, 1978.
7. Kawaguchi M., Sumi Y., Yokomi H. Progr.Theor.Phys., 1967, 38, p. 1178; 1967, 38, p. 1183; Phys.Rev., 1968, 168, p. 1556.
8. Kapshay V.N., Sidorov A.V., Skachkov N.B. JINR, E2-11932, Dubna, 1978.
9. Goloskokov S.V. et al. Particles and Nucleus, 1977, 8, p. 969.
10. Bracci E. et al. Compilation of Differential Cross Section π-Induced Reaction. Preprint CERN-HERA 75-2, 1975.

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