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THREE-REGGEON DESCRIPTION OF INCLUSIVE PROTON SPECTRA

A. B. Kaidalov, Yu. F. Pirogov, N. L. Ter-Isaakyan, and V. A. Khoze
Leningrad Institute of Nuclear Physics, USSR Academy of Sciences
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The study of $pp \to pX$ hadronic spectra near the kinematic boundary $s \gg M^2 \gg m^2$, $-t \lesssim m^2$ within the framework of the three-reggeon (TR) scheme [1, 2] is of interest both from the point of view of a test of scaling in inclusive reactions (i.e., the dependence of the spectra on only $x = 2p/\sqrt{s} \simeq 1 - M^2/s$) and in connection with the possibility of obtaining information on the three-reggeon vertices. Particular interest attaches to the three-pomeron vertex, the behavior of which at small t is essential for the understanding the character of the asymptotic behavior of strong interactions [3 - 5].

In earlier analyses, the data at $s = 20 - 60$ GeV^2 [6, 7] and the new ISR data at $s = 940$ and 1995 GeV^2 [8] were described differently assuming appreciable PPR and RRP contributions and small or nonexistence of PPP and RRR contributions (here P is the Pomeranchuk pole and R stands for the secondary trajectories P', ρ, ω, A_2, etc.).

It is shown in the present paper that a simultaneous analysis of these data leads to an entirely different relation between the vertices, namely, to appreciable PPP and RRR, the presence of RRP, and smallness or nonexistence of PPR.

The inclusive cross section is given in the TR model by [1, 2]

$$E\frac{d^3\sigma}{d^3p} = \sum_{ijk} G_{ijk}(t)(1-x)^{\alpha_k(0)-\alpha_i(t)-\alpha_j(t)}\left(\frac{s}{s_0}\right)^{\alpha_k(0)-1} = \Sigma(ijk);$$
$$G_{ijk}(t) = \frac{1}{16\pi^2}\beta_i(t)\beta_j(t)\beta_k(0)\eta_i(t)\eta_j^*(t)\,g_{ijk}(t); \quad i, j, k = P, R... \qquad (1)$$

where $\beta_i(t)$ are the vertices of the connection of the Regge poles with

$$p\left(\sigma_{tot}^{pp} = \sum_i \beta_i^2(0)(s/s_0)^{\alpha_i(0)-1}\right),$$

$\eta_i(t)$ is the signature factor, $g_{ijk}(t)$ is the three-reggeon vertex[1)], and $s_0 = 1$ GeV^2.

A characteristic feature of the proton spectrum at $s = 940$ GeV^2 and $s = 1995$ GeV^2 is the sharp peak at $x \geq 0.9$ and $0.2 \leq p^2 \leq 1$ (GeV/c)^2. This peak was described in [8] by the term PPR. However, the PPR contribution increases like $s^{-1/2}$ with decreasing s, and use is made of the data at $s = 20 - 60$ GeV^2, we can show that its upper bound at $s = 1995$ GeV and $x \simeq 0.9 - 0.97$ is $\leq 15\%$. This makes it necessary to introduce PPP. As a background for the latter we use RRR and RRP and consider variants with and without PPR. The contributions of the RRP and PRR interference terms are neglected since, first, there are indications that they are small [9] and, second, our analysis shows that allowance for these terms can change g_{PPP} by only $\sim 20\%$.

We present the results of the data reduction. The quantities $G_{iik}(t)$ were parametrized in the form

$$G_{iik}(t) = G_{ik}(0)e^{R^2_{ik}t},$$

and the values chosen for the Regge-pole parameters were $\alpha_P(0) = 1$, $\alpha_R(0) = 0.5$, $\alpha_P'(0) = 0$ and 0.15 (GeV/c)$^{-2}$ and $\alpha_R'(0) = 0.75$ (GeV/c)$^{-2}$. The decrease in the slopes takes into account the

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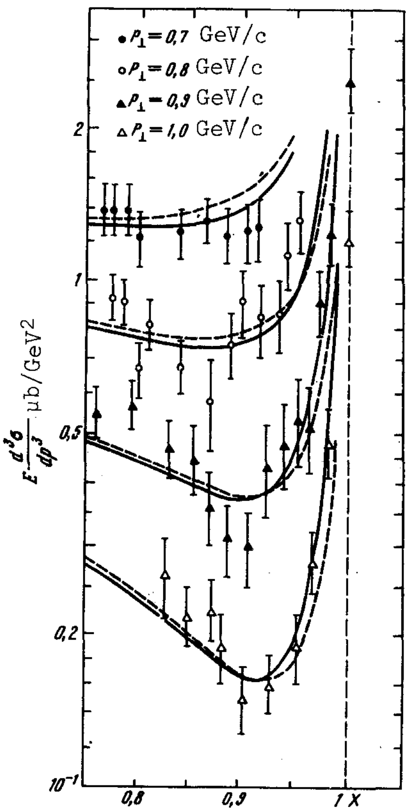
[1)] The quantities $g_{ijk}(t)$ are connected in our normalization with the r(t) used in [5] by the following relation: $g_{PPP}(t) = \sqrt{8\pi}\,r(t)$.

		PPP		RRP	RRR
		PPR = 0	PPR=PPP		
G_{ik} μb/GeV^2	$\alpha_P'(0) = 0$	0,5	0.45	4,7	32
	$\alpha_P'(0) = 0{,}15\ (\mathrm{GeV/c})^{-2}$	0.64	0,57		
R_{ik}^2 (GeV/c)$^{-2}$	$\alpha_P'(0) = 0$	4		0	1,2
	$\alpha_P'(0) = 0{,}15\ (\mathrm{GeV/c})^{-2}$	3,5			



the influence of the branch points in the considered region of relatively large P^2. The obtained parameter values are listed in the table. The description of the ISR data at s = 1995 GeV^2 with the aid of these parameters is shown in the figure. The same parameter give a reasonable description of the data at s = 940 GeV^2 and s = 20 - 60 GeV^2. It is seen from the table that $G_{PP}(0)$ changes very little when $\alpha_P'(0)$ is varied and PPR is introduced. The term RRR turns out to be appreciable and must be taken into account to describe the energy dependence of the spectra at $x \approx 0.8$.

In conclusion, we present a few estimates of the absolute scale of the obtained three-pomeron vertex $g_{PPP}(t)$

If $g_{PPP}(0) \neq 0$, then the contribution of the TR region to the total cross section, assuming $\alpha_P(0) = 1$ when $\alpha_P' \ln(s/M_0^2) >> R_{PP}$ takes the form ($M_0^2 \approx 4$ GeV)

$$\sigma_{TP}^{P} = \frac{\pi G_{PP}(0)}{\alpha_P'(0)} \ln\ln\frac{s}{M_0^2},$$

The main contribution to the cross section is made by the region of small t, where $\alpha_P' \approx 0.4$ GeV/c)$^{-2}$. In this case $\sigma_{TP}^{P} \approx \sigma_{tot}^{pp}(1/10)\ln\ln(s/M_0^2)$. For the theory to be self-consistent we must put $\alpha_P(0) = 1 - \varepsilon$ ($\varepsilon > 0$).

In [4] there are arguments favoring the assumption that $\varepsilon \gtrsim \eta$, where $\eta = g_{PPP}(0)/32\pi\alpha_P'(0)$. At the indicated values of the parameters, $\eta = 10^{-3}$.

On the other hand, if $\alpha_P = 1$, then we must have $g_{PPP}(t) \sim t$ as $t \to 0$ [3]. Since there are at present no data in the region $-t < 0.2$ (GeV/c)^2, this question cannot be answered uniquely. We have therefore considered also the parametrization $g_{PPP}(t) = A|t|\exp(\bar{R}_{PP}^2 t)$, and obtained $A = 1.5 - 1.8$ GeV^{-3} and $\bar{R}_{PP}^2 = 2 - 3$ (GeV/c)$^{-2}$. The quantity A characterizes the contribution of the enhanced branch point to the forward scattering amplitude. In particular [10]

$$\sigma_{tot}(s) = s^{-1}\,\mathrm{Im}\,T(s,0) \approx \sigma_{tot}(\infty)\left\{1 - \frac{\beta_P^2(0)}{32\pi\left(R_0^2 + \alpha_P'(0)\ln\frac{s}{s_0}\right)}\right. \qquad (2)$$

$$\left.\times\left[\left(1 - \frac{\bar{\beta}(0)}{\beta_P(0)}\right)^2 + \sigma_{in,R}^{P}(pp)/\sigma_{ee}^{P}(pp)\right]\right\},$$

where $\bar{\beta}(0) = A/2\alpha_P'(0)$, $\sigma_{in,R}^{P}(pp)$ is the cross section for diffraction production of resonances in pp collisions, and $\sigma_{e\ell}^{P}(pp)$ is the contribution of the vacuum pole to the elastic pp-scattering cross section. We obtain $\bar{\beta}(0)/\beta_P(0) \approx 0.2$ at $\alpha_P'(0) = 0.4$ (GeV/c)$^{-2}$.

We note that, strictly speaking, at the existing energyies the quantity $g_{PPP}(t)$ describes not the contribution of the Pomeranchuk pole, but the effective contribution of P and of the accompanying branch points, and may in general not vanish when $t \to 0$. In this case, however, the quantity $d^2\sigma/dtdM^2$ at fixed $M^2 >> M_0^2$ and small t should decrease logarithmically with increasing s. Measurement of the proton spectra at high energies in the region of small t (<0.1 $(GeV/c)^2$) is therefore of considerable interest.

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ALLOWANCE FOR FINAL-NUCLEUS INSTABILITY IN QUASIELASTIC KNOCKOUT OF PROTONS FROM Li^6 NUCLEUS

Yu. D. Bayukov, L. S. Vorob'ev, V. M. Kolybasov, G. A. Leksin, N. Ya. Smorodinskaya, V. L. Stolin, and V. B. Fedorov
Institute of Theoretical and Experimental Physics
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There are two points in which the experimental data on the quasielastic knockout of protons from the Li^6 nucleus do not agree with the concepts of the dominant role of the pole mechanism (Fig. 1a) at small momentum transfers: (a) The angular distributions in the reaction $Li^6(p, 2p)$, unlike the reactions with other light nuclei, cannot be satisfactorily described by a scheme in which the contribution of all the diagrams other than the pole diagram is assumed to be a slowly varying function of the momentum transfer and is approximated by a certain constant [1] (a similar result is obtained also in the impulse approximation with disotrted waves). The theory leads to a sharp minimum in the angular distribution, while experiment shows only a noticeable dip (see below). Nor is it possible to explain the asymmetry in the distribution with respect to the excitation energy of the residual nucleus [2]. (b) An investigation of the reaction $Li^6(\pi^-, \pi^-p)$ [3] has revealed that although a number of the distributions that are sensitive to the reaction mechanism agree well with the predictions based on diagram 1a, the values of the reduced proton widths θ_p^2 and θ_s^2 differ noticeably from the reduced widths obtained from data on other reactions, if it is assumed that all the p-wave events pertain to a transition to the ground state of He^5, while all the s-state pertain to higher excitation energies.

Since the indicated deviations are observed only in reactions with Li^6, it is natural to attempt to find an explanation in the singularities connected with this nucleus. When a proton is knocked out of Li^6, the produced He^5 is unstable against decay into $He^4 + n$. It can therefore be assumed that an appreciable contribution is made by a diagram with direct breakup of Li^6 into three particles ($He^4 + n + p$), for then the singularity with respect to the momentum transferred from the initial nucleus to the final nuclear system $He^4 + n$ is closer than in the diagram of Fig. 1a. Taking the cluster character of the Li^6 nucleus into account ($\alpha + d$), it is natural to choose for the vertex $Li^6 \to He^4 + n + p$ the model $Li^6 \to He^4 + d$, $d \to n + p$. The advantage of this mechanism is that it ~~is~~ leads, in accord with the experimental data [3], to an isotropic distribution relative to the Treiman-Yang angle (owing to the s-wave character of both nuclear vertices).

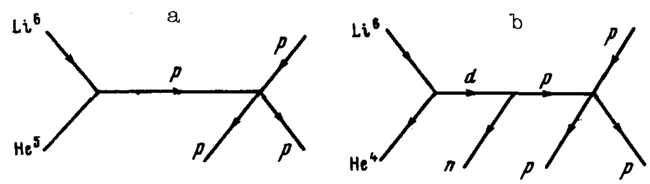

Fig. 1

If we assume for $\alpha + d$ in Li^6 a Gaussian wave function with parameter $\gamma = (1/36\ MeV/c)^2$