Energy dependence of the ρ-trajectory intercept

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The forward πN charge-exchange differential cross section is studied in the framework of a recent model for the ρ trajectory. Negative results shed doubt on the proposed nondiffractive renormalization mechanism for secondary Reggeons.

It has recently been argued[1] that a nondiffractive renormalization procedure due to particle-production thresholds, similar to that formerly proposed for the Pomeron,[2] might be applicable to the ρ trajectory. Within this hypothesis the ρ effective intercept increases sizeably with energy (of the order of 0.2 units of angular momentum) due to the opening of new channels associated with the inelastic production of pairs of particles with strangeness, baryon, charm, and other flavor quantum numbers. These effects are suggested to be more important than those arising from terms higher than the cylinder in the topological expansion.[3]

Even if the model of Ref. 1 gives, in particular, a result compatible with present $\Delta\sigma = \sigma_{\pi^- p} - \sigma_{\pi^+ p}$ data,[4] we want to point out here its implications for the forward πN charge-exchange differential cross section.

In Fig. 1 we present $\Delta\sigma$ data[5] and the three-stepped fit of Ref. 1 with $\alpha_\rho^{(0)} = 0.45$, $\alpha_\rho^{(1)} = 0.61$, and $\alpha_\rho^{(2)} = 0.71$, respectively, together with the exact prediction obtained from the correct imaginary part of the model amplitude[2]

$$s\Delta\sigma = Bs^{\alpha_\rho^{(0)}}[\theta(\ln s - b_D) + g_K e^{-b_K\alpha_\rho^{(0)}}(\ln s - b_K - b_D)\theta(\ln s - b_K - b_D) + g_B e^{-b_B\alpha_\rho^{(0)}}(\ln s - b_B - b_D)\theta(\ln s - b_B - b_D) + \cdots] , \quad (1)$$

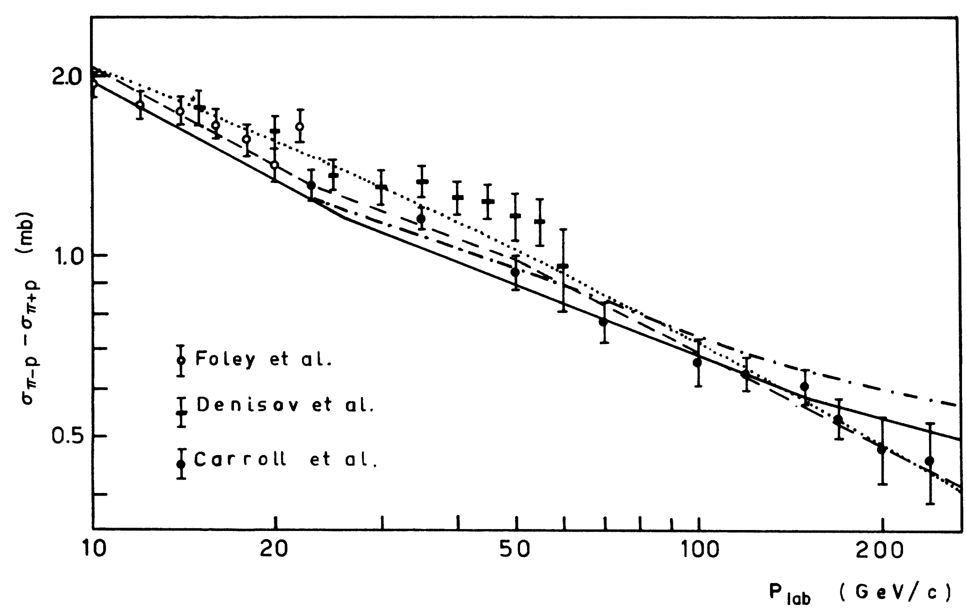

FIG. 1. Difference of $\pi^- p$ and $\pi^+ p$ total cross sections (Ref. 5); three-stepped fit of Ref. 1 (solid line), result from Eq. (1) (dashed-dotted line), fit with model of Ref. 10 (dotted line), result from Eq. (1) with one-loop correction of ρ propagator added (dashed line).

where the residue B is adjusted to match $\Delta\sigma$ at 10 GeV/c, and the remaining parameters are taken from Refs. 1 and 2. This last prediction is seen to be well above experimental points at the higher energies.

In Fig. 2 we show results for $d\sigma_{\text{CEX}}/dt|_{t=0}$ computed using an unsubtracted dispersion relation.[6] For the model of Ref. 1 we have first assumed that no other flavor thresholds occur beyond the baryon-antibaryon threshold, so that the $\alpha_\rho^{(2)}=0.71$ behavior is supposed to hold up to asymptotic energies. As seen in the figure, the prediction obtained in this way is completely outside error bars[7] in experimental data[8] by a factor of four at the highest available energy. Nevertheless, one can think that the completely flavored secondary Regge singularity corresponds to the bare Reggeon-field-theory input pole[9] and that diffractive- as well as absorptive-type contributions will then renormalize the ρ intercept downwards to an approriate final asymptotic value. However, it is easy to be convinced that if these effects were not relevant at present experimental energy ranges, they ought to change dramatically the asymptotic behavior; e.g., we have plotted in Fig. 2 the result obtained arbitrarily assuming a smooth $\alpha_\rho=0.5$ behavior from $p_{\text{lab}}=500$ GeV/c onwards and it still misses Fermilab data by a factor of two. Of course the prediction with the exact amplitude, Eq. (1), would correspondingly be still higher.

Looking back at Fig. 1 one sees that the deviation from pure Regge-pole behavior, if any, should show a slight curvature just opposite to that of the above-mentioned proposal. In this connection a model such as that introduced in Ref. 10 seems more adequate. In this model threshold effects are due to the appearance of large rapidity gaps in the s-channel unitarity relation. Since the first correction, which has the diffractive sign, exhausts itself before the next threshold contribution becomes significant, the net result is a ρ intercept continuously decreasing to an asymptotic value ~0.5 after an enhancement in the Serpukhov range (see Fig. 1). In this way a prediction for $d\sigma_{\text{CEX}}/dt|_{t=0}$ has been given[10] which is in reasonable agreement (within 20%) with latest Fermilab data as shown in Fig. 2.

On the other hand, it is worth noting that sizeable effects due to ρ-Pomeron interactions as given by Reggeon calculus can be obtained at energies available at present. In fact, the addition to the proposed nondiffractive renormalization [Eq. (1)] of a term $-Bs^{\alpha_\rho^{(0)}}G^2(\ln s-\Delta)^2$ corresponding to a one-loop correction to the ρ-pole propagator (the minus sign coming from the dominance of absorptive contributions) causes a decrease of the

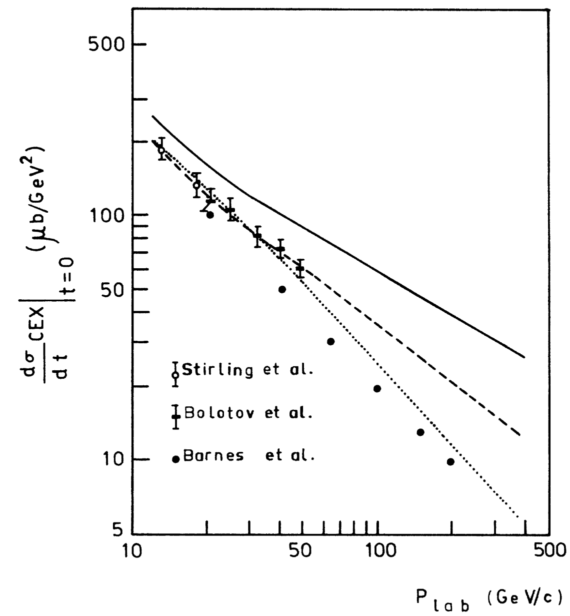

FIG. 2. Forward πN charge-exchange differential cross section (Ref. 8); prediction of the model of Ref. 1 with $\alpha_\rho^{(2)}=0.71$ asymptotic behavior (solid line), prediction of the same model with $\alpha_\rho=0.5$ for $p_{\text{lab}}>500$ GeV/c (dashed line), prediction of the model of Ref. 10 (dotted line).

effective ρ intercept quite close to that of Ref. 10, after the enhancement due to $K\bar{K}$ production. This mechanism is shown in Fig. 1, where B has now been adjusted to match the $\Delta\sigma$ value of Ref. 10 at 10 GeV/c and we have taken $G^2=0.1$ and $\Delta=4$. In this way a good prediction can also be obtained for $d\sigma_{\text{CEX}}/dt|_{t=0}$. Note that this effect is stronger than the analogous correction for the Pomeron propagator[11] because of the larger triple-Reggeon coupling and appears at a lower energy since no appreciable threshold in rapidity is required for the ρ pole due to duality arguments.

In conclusion, we remark that our calculations show that an increasing ρ intercept is not consistent with present data and that important corrections coming from terms higher than the cylinder should alter the scheme proposed in Ref. 1.

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[1]J. Finkelstein and J. Koplik, Phys. Rev. D 14, 1467 (1976).

[2]J. W. Dash and S. T. Jones, Nucl. Phys. B120, 345 (1977).

[3]G. Veneziano, Phys. Lett. 52B, 220 (1974); G. F. Chew and C. Rosenzweig, Phys. Lett. 58B, 93 (1975).

[4]Provided one leaves Serpukhov data aside.

[5]K. J. Foley *et al.*, Phys. Rev. Lett. 19, 330 (1967); S. P. Denisov *et al.*, Nucl. Phys. B65, 1 (1973); A. S. Carroll *et al.*, Phys. Lett. 61B, 303 (1976).

[6]For a discussion of this choice see A. García, L. Masperi, and N. Parga, Nuovo Cimento 25A, 377 (1975).

[7]For Fermilab data we have not drawn error bars since they are not estimated by the authors.

[8]A. V. Stirling *et al.*, Phys. Rev. Lett. 14, 763 (1965); V. N. Bolotov *et al.*, Nucl. Phys. B73, 365 (1974); A. V. Barnes *et al.*, Phys. Rev. Lett. 37, 76 (1976).

[9]J. W. Dash and J. Koplik, Phys. Rev. D 12, 785 (1975).

[10]A. García, C. A. García Canal, L. Masperi, and N. Parga, Nuovo Cimento 32A, 1 (1976).

[11]A. García, C. A. García Canal, and L. Masperi, Phys. Lett. 66B, 442 (1977).