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ISOSCALAR EXCHANGE IN VECTOR-MESON PRODUCTION

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Abstract: The $I = 0$ exchange contributions to K* (888), $\bar{K}$*(888) and ρ-production on nucleons are discussed. The natural-parity exchange components are successfully related using SU(3) and exchange degeneracy for the ω and f_0 Regge poles. Limits on a possible pomeron exchange component are presented.

1. Introduction

Intermediate and high-energy two-body reactions are controlled mainly by the exchange-channel particle spectrum and couplings. No comprehensive theory exists for such scattering amplitudes, although the Regge pole approach is a very instructive ingredient. To elucidate the structure and regularities of such scattering amplitudes, it is best to proceed by first extracting features of the amplitudes directly from data, and then making comparisons with general model approaches such as the Regge-pole exchange-degeneracy SU(3) package. Indeed, it appears [1,2] that such a package is approximately correct for overall helicity-flip ($n = 1$) amplitudes while substantial modifications are needed in overall non-flip ($n = 0$) amplitudes. The present work discusses the situation for isoscalar exchange vector production based on a selection of presently available data [3–15].

Certain features of $I_t = 0$ vector production have been noticed previously; $\pi N \to \rho N$ ($I_t = 0$) is dominantly natural-parity exchange and has an energy and t dependence [15] consistent with the simple model of an ω Regge-pole exchange [2] which explains the dip in $d\sigma/dt$ near $t = -0.4$ (GeV/c)^2; $K^{\pm}p \to K^{*\pm}p$ are known to be dominantly natural-parity exchange in contrast to the charge-exchange reactions $K^+n \to K^{*0}p$ and $K^-p \to K^{*0}n$. The energy dependence of $K^-p \to K^{*-}p$ leads to a higher-lying effective trajectory for natural-parity exchange than for unnatural-parity exchange [14,16]. To study more systematically such features the t-channel isospin amplitudes will be exploited. Choosing the natural-parity mesons (f_0, ω, A_2, ρ) as representations* of isospin and signature in the t-channel, gives isospin relations for amplitudes:

* For footnote, see next page.

$$\mathrm{K^+p \to K^{*+}p} \qquad = -\mathrm{f_0} + \omega - \mathrm{A_2} + \rho\,, \tag{1}$$

$$\mathrm{K^+n \to K^{*+}n = K^0p \to K^{*0}p} \qquad = -\mathrm{f_0} + \omega + \mathrm{A_2} - \rho\,, \tag{2}$$

$$\mathrm{K^+n \to K^{*0}p} \qquad = -2\mathrm{A_2} + 2\rho \tag{3}$$

$$\mathrm{K^-p \to K^{*-}p} \qquad = \mathrm{f_0} + \omega + \mathrm{A_2} + \rho\,, \tag{4}$$

$$\mathrm{K^-n \to K^{*-}n = \overline{K}{}^0p \to \overline{K}{}^{*0}p} \qquad = \mathrm{f_0} + \omega - \mathrm{A_2} - \rho\,, \tag{5}$$

$$\mathrm{K^-p \to \overline{K}{}^{*0}n} \qquad = 2\mathrm{A_2} + 2\rho\,, \tag{6}$$

$$\pi^+\mathrm{p} \to \rho^+\mathrm{p} \qquad = 2\gamma(\omega - \mathrm{A_2})\,, \tag{7}$$

$$\pi^-\mathrm{p} \to \rho^-\mathrm{p} \qquad = 2\gamma(\omega + \mathrm{A_2})\,, \tag{8}$$

$$\pi^-\mathrm{p} \to \rho^0\mathrm{n} \qquad = -2\sqrt{2}\gamma\mathrm{A_2}\,. \tag{9}$$

SU(3) gives** the restriction $\gamma = 1$ while for exchange degenerate Regge poles $\mathrm{Im\,f_0} = \mathrm{Im}\,\omega$ and $\mathrm{Im\,A_2} = \mathrm{Im}\,\rho$. Labelling the reactions as above, the $I = 0$ exchange differential cross sections may be extracted:

$$\begin{aligned} \sigma^0(\mathrm{K^*}) &= \tfrac{1}{2}(\sigma_1 + \sigma_2) - \tfrac{1}{4}\sigma_3\,, \\ \sigma^0(\overline{\mathrm{K}}{}^*) &= \tfrac{1}{2}(\sigma_4 + \sigma_5) - \tfrac{1}{4}\sigma_6\,, \\ \sigma^0(\rho) &= \tfrac{1}{2}(\sigma_7 + \sigma_8) - \tfrac{1}{2}\sigma_9\,. \end{aligned} \tag{10}$$

As well as isolating the exchange isospin, it is advantageous to exploit the measured vector-meson density-matrix elements to separate different parity-exchange combinations. It is convenient to define***

* For the unnatural-parity exchange amplitudes replace $(\mathrm{f_0},\omega,\mathrm{A_2},\rho)$ by $(\eta,\eta',\pi,\mathrm{B})$ respectively for the singlet states and $(\mathrm{D},\mathrm{Z_0},\mathrm{A_1},\mathrm{Z_1})$ respectively for the triplet states (where Z_I are $J^P = 2^-$ mesons of isospin I).

** For the π-exchange contribution SU(3) for the production amplitudes applies equally of course. This leads to a broken SU(3) prescription for relating ρ and K* widths by comparing the π-pole exchange contribution to ρ and K* production integrated over the whole Breit–Wigner resonance shape. This yields $m_\rho^2\,\Gamma_\rho/q_\rho = 2m_{\mathrm{K^*}}^2\,\Gamma_{\mathrm{K^*}}/q_{\mathrm{K^*}}$ where q is the decay momentum to $\pi\pi$ and $\mathrm{K}\pi$ respectively. This expression agrees better than the naive phase-space corrected decay coupling ratio $m_\rho\Gamma_\rho/q_\rho^3 = 2m_{\mathrm{K^*}}\Gamma_{\mathrm{K^*}}/q_{\mathrm{K^*}}^3$.

*** S-wave contributions under the ρ or K* can be corrected by using $\rho_{\mathrm{U}} + \rho_{\mathrm{N}} = 1 - \rho_{\mathrm{SS}}$ where ρ_{SS} may be taken from estimates of the S– and P–wave phase shifts. From the decay moments in the presence of S waves, the combination $\rho_{\mathrm{N}} + \frac{1}{3}\rho_{\mathrm{SS}}$ is observable. In practice $\rho_{\mathrm{SS}} \lessapprox \frac{1}{7}\rho_{00}$ and so $\frac{1}{3}\rho_{\mathrm{SS}}$ can safely be neglected within the statistical accuracy of the data considered in this paper.

For pure P-wave production, these quantities are bounded by $1 > \rho_{\mathrm{N}} > 0$ and $1 > \Delta^2 > 0$ where ρ_{N} and Δ^2 are invariant for s- or t-channel helicity frames. This implies $1 > \rho_{00} > 0$ and $1 > \rho_- > 0$ for both such frames.

$$\begin{aligned}
\rho_N &= \rho_{11} + \rho_{1-1} , \\
\rho_- &= \rho_{11} - \rho_{1-1} , \\
\rho_U &= \rho_{00} + \rho_- = 1 - \rho_N , \\
\Delta^2\rho_U &= 4\,[\rho_{00}\rho_- - 2(\mathrm{Re}\,\rho_{10})^2] .
\end{aligned} \tag{11}$$

The product $\sigma_N = \rho_N\,(\mathrm{d}\sigma/\mathrm{d}t)$ gives (to order $1/s$) the natural-parity exchange contribution to the differential cross section, while σ_0 and σ_- likewise give the unnatural-parity exchange contributions in meson helicity 0 and 1 respectively. The isospin relations (10) apply equally to the partial differential cross sections σ_N, σ_U, σ_0 and σ_-.

2. Data analysis

Some data for reactions (1)–(9) exist up to 17 GeV/c, but to facilitate the comparison between different reactions two nominal momenta, 4.5 and 10 GeV/c where chosen. The differential cross sections at nearby energies were scaled to the nominal momenta using a p_{lab}^{-2} momentum dependence. Data from 3.9 to 5.5 GeV/c (refs. [3–11]) were combined to 4.5 GeV/c and 9 to 12 GeV/c data [12–14] were similarly combined to 10 GeV/c. Then the resulting data on $\mathrm{d}\sigma/\mathrm{d}t$, ρ_{00}, ρ_{1-1} and $\mathrm{Re}\,\rho_{10}$ for each reaction in either energy band were interpolated by smooth curves as functions of t with typical errors assigned at a few t-values. Since the data were presented in the $t$channel helicity frame more often than in the s-channel helicity frame, the interpolations were performed in the t-channel frame and the s-channel frame density-matrix elements were obtained by crossing (after checking that the bounds were satisfied).

A problem that needs special discussion is the normalization of $\mathrm{d}\sigma/\mathrm{d}t$ for these data. To compare K^* production in different charge states and at different energies the ideal procedure would be to take a conservative cut on the K^* mass (say 890 ± 50 MeV or even narrower) and a cut on the momentum transfer [e.g., $t = -0.1$ to -1.0 (GeV/c)^2] to avoid (i) uncertainties at small t due to deuterium effects or missed recoil tracks and (ii) large t-values where uncertainties due to reflections may be more important. Then the events in this sample should be normalized absolutely (with no background subtraction). The cross section so obtained should be clearly quoted in the experimental papers. For theoretical comparisons between ρ, ω and K^* production, it is also necessary to estimate the total resonance production cross section. This involves model-dependent estimates of (a) the contribution of the resonance shape outside the above mass cut, (b) the background due to S-wave contributions or due to reflections and (c) the corrections to be applied to small t-data.

In view of the varying prescriptions employed by different experimental groups, ratios of differential cross sections from a single experiment have been used as far as possible to constrain the normalizations. Thus $K^+p \to K^{*+}p$, $K^+n \to K^{*+}n$ and

$K^+n \to K^{*0}p$ are obtained in the 4.6 GeV/*c* K^+d experiment [4]; $K^0p \to K^{*0}p$ and $\bar{K}^0p \to \bar{K}^{*0}p$ in the K^0_L beam experiment [5]; $K^-p \to K^{*-}p$ and $K^-p \to \bar{K}^{*0}n$ in several K^-p experiments [6,14] and $\pi^-p \to \rho^-p$ and $\pi^-p \to \rho^0n$ in several π^-p experiments [10,15]. In the 4.5 GeV/*c* energy band, the K^+d data [4] were increased by 1.25 in normalization to agree with the K^+p data [3]. Then, since K^0p and K^+n cross sections should be identical, the K^0_Lp preliminary data [5] (taken to be at an average momentum of 5.3 GeV/*c*) had to be increased by 2.5 in normalization. Increasing the $\bar{K}^0p$ data normalization in this way necessitates an increase of about 2.5 for the K^-n data [8b,c,d]. The average normalization of the K^+p and K^-p experiments [3,6,7] was unchanged. The $\pi^-p \to \rho^0n$ data at 4.4 GeV/*c* (ref. [10]) were normalized using the π-pole extrapolation [17], while the ratio to $\pi^-p \to \rho^-p$ was taken unchanged from the data. For $\pi^+p \to \rho^+p$ the average $(\times p^2_{\text{lab}})$ of the data was increased in normalization by 1.3 to equate the unnatural-parity cross section with that for $\pi^-p \to \rho^-p$. In the 10 GeV/*c* band, the K^* production data [12–14] were not renormalized while the experiments [15] at 6 and 16 GeV/*c* which measured simultaneously $\pi^-p \to \rho^-p$, $\pi^-p \to \rho^0n$ and $\pi^+p \to \rho^+p$ were relied upon for extracting the $I_t = 0$ ρ-production amplitudes.

A check on the normalization of such data can be obtained from the isospin triangle bounds [18], particularly when applied to the partial differential cross sections σ_N, σ_0 and σ_-. In practice the large errors made this rather imprecise. A further, more theoretical, check comes from comparing the π-exchange component in the various reactions.At small t in σ_0, the π-exchange peak should be in the ratio $1 : 1 : 4 : 1 : 1 : 4 : 4\gamma^2 : 4\gamma^2 : 8\gamma^2$ for reactions 1 to 9 respectively. At small t, however, reactions, (2), (3), (5), (7) and (8) suffer either deuterium effects or recoil track losses, while at larger t other exchange contributions can reduce the extent of π-exchange dominance. Within such uncertainties, the data normalization chosen above agrees with the π-exchange constraints.

The data interpolations and errors are shown in fig. 1 for σ_N and in fig. 2 for σ_U. The different reactions are presented multiplied by factors which equalize the $I_t = 1$ exchange contribution. Thus, for fig. 2. the equality of the curves for the different reactions shows that the unnatural-parity exchange contributions are consistent with pure $I_t = 1$ exchange within the rather large errors. This could be interpreted as a dominance of the π-exchange contribution. On the contrary, fig. 1 shows for σ_N a dominance of isoscalar exchange. At 4.5 GeV/*c*, the isoscalar contributions are extracted according to eq. (10) and presented in fig. 3; σ^0_N contributes 90–100% of the isoscalar exchange cross section σ^0 for K^*, $\bar{K}^*$ and ρ production. At 10 GeV/*c* there are no data on the K^+n and K^-n channels. To extract $\sigma^0_N(K^*)$ and $\sigma^0_N(\bar{K}^*)$, one proceeds by assuming that the $K^+n \to K^{*+}n$ contribution is equal to that for $K^+p \to K^{*+}p$ and similarly [6a]for $K^-n \to K^{*-}n$ from $K^-p \to K^{*-}p$. For $\sigma^0(\rho)$, a previous interpolation [2] of the 6 and 16 GeV/*c* cross sections is shown in fig. 4. This interpolation has rather large errors, particularly at large t where it underestimates the data. The resulting isoscalar contribution $\sigma^0(\rho)$ at 10 GeV/*c* is presented in fig. 3.

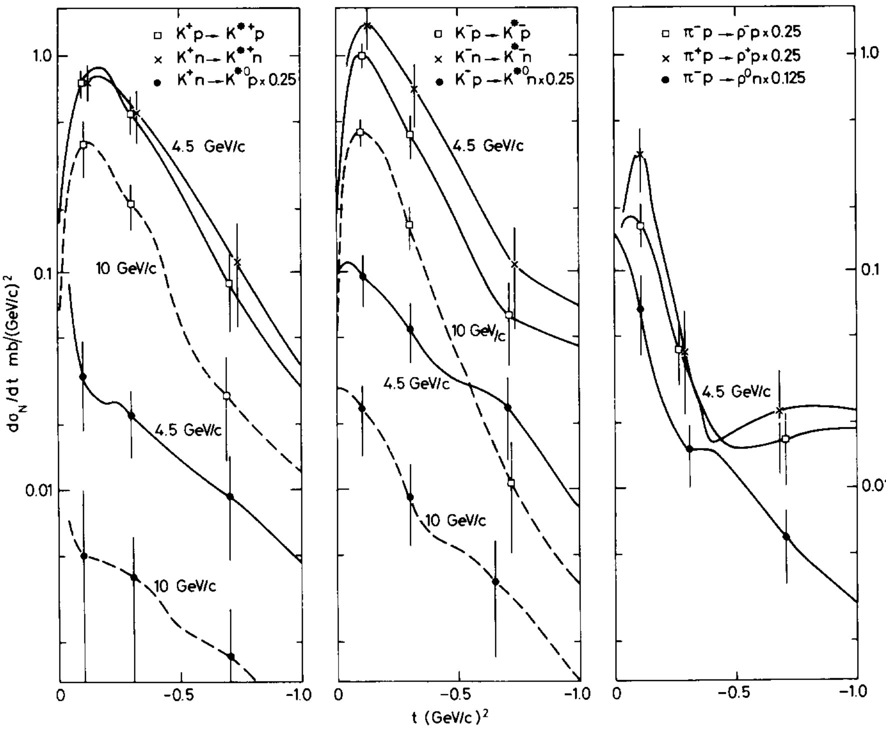

Fig. 1. The natural-parity exchange contribution to vector-meson production differential cross sections $(\rho_{11}+\rho_{1-1})\,d\sigma/dt$. Within each of the two energy bands 3.9 to 5.5 GeV/c and 9 to 12 GeV/c, the data [3–14] were scaled as p_{lab}^{-2} to the nominal momenta 4.5 GeV/c and 10 GeV/c respectively. The resulting average distributions are represented by the interpolating curves in t with typical errors at a few t-values. Continuous curves represent 4.5 GeV/c data and dashed curves 10 GeV/c data. The data have been multiplied by the factors shown so as to equalize the isovector-exchange contribution to each of the nine reactions.

The energy dependence of $[\sigma_N^0(K^*)+\sigma_N^0(\bar{K}^*)]$from 4.5 to 10 GeV/$c$ is shown by the effective trajectory $\alpha_{\text{eff}}(t)$ in fig. 5. The unnatural-parity cross sections in fig. 2 fall by about a factor 7 from 4.5 to 10 GeV/c although errors are large. This corresponds to $\alpha_{\text{eff}}^{U} \sim -0.3$.

3. A simple exchange-degenerate Regge approach

The data presented above show several simple features. The dominance of natural-parity exchange for $I_t = 0$ and of unnatural-parity exchange for $I_t = 1$ is well known. Here details of the $I_t = 0$ natural-parity exchange will be studied. In particular a simple exchange degenerate ω–f_0 Regge-pole exchange approach reproduces exceedingly well the over-all features of the data.

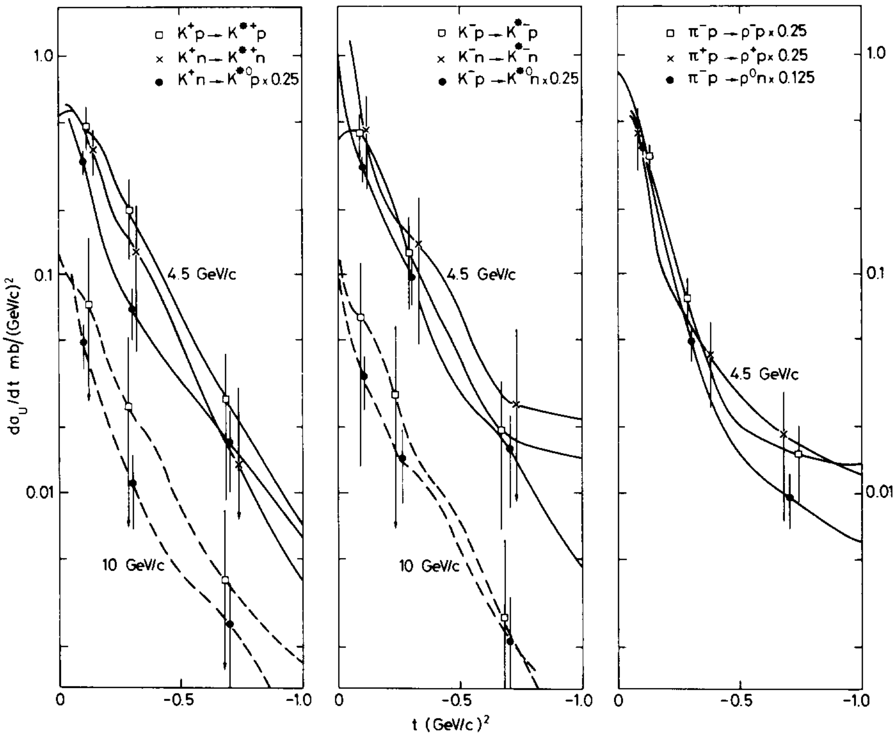

Fig. 2. The unnatural-parity exchange contribution $(\rho_{00}+\rho_{11}-\rho_{1-1})$ $d\sigma/dt$ presented as for fig. 1.

(i) Such an ω–f_0 exchange contribution would be expected to couple dominantly to the single helicity-flip ($n=1$) amplitude since the ω–f_0 coupling to nucleons is predominantly non-flip while the coupling at the meson vertex is necessarily helicity flip. This $n = 1$ amplitude will then give a forward dip at $t' = 0$ in $\sigma^0(K^*)$, $\sigma^0(\bar{K}^*)$ and $\sigma^0(\rho)$ as observed.

(ii) Exchange degenerate ω and f_0 contributions have a phase difference of 90° and so lead to equality of $\sigma_N^0(K^*)$ and $\sigma_N^0(\bar{K}^*)$. Fig. 3 shows that this is valid within errors. Coherent production of $K^{*\pm}$ on deuterium [19], which isolates $I_t = 0$, also supports this equality.

(iii) The $\sigma_N^0(\rho)$ has only ω-exchange contributions and taking account of the SU(3) factor gives the relation

$$\sigma_N^0(\rho)/[\sigma_N^0(K^*)+\sigma_N^0(\bar{K}^*)] = 4|\omega|^2/[|\omega-f_0|^2+|\omega+f_0|^2]$$

$$= \frac{4|1-e^{-i\pi\alpha(t)}|^2}{|-2|^2+|-2e^{-i\pi\alpha(t)}|^2}$$

$$= 1-\cos\pi\alpha(t)\,.$$

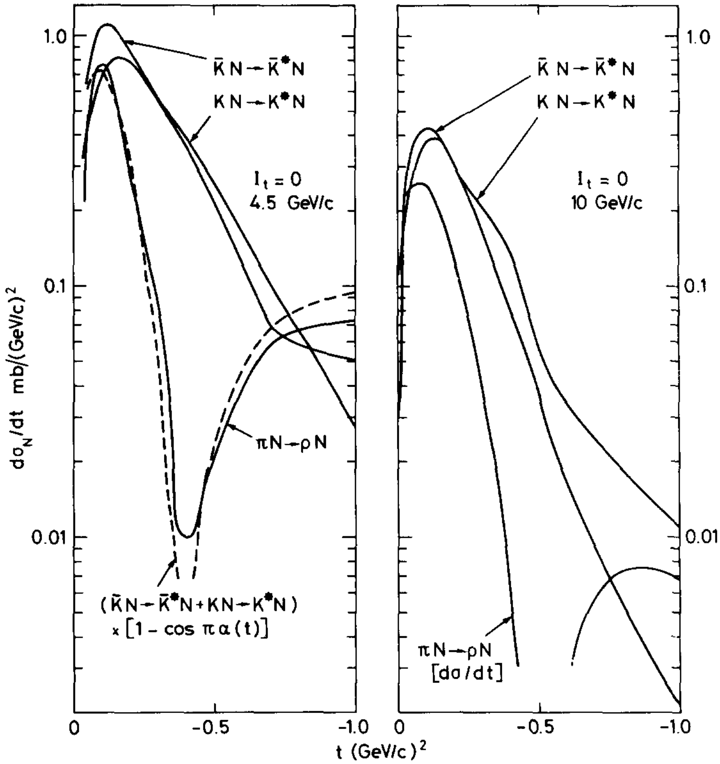

Fig. 3. The isoscalar exchange contributions to natural-parity exchange vector-meson production. The continuous curves are evaluated from the data interpolations of fig. 1 except for $\pi N \to \rho N$ at 10 GeV/c where the specific fit shown in fig. 4 was used as an interpolation. The dashed curve for $\pi N \to \rho N$ at 4.5 GeV/c is estimated from the average K^* and K^* production using an SU(3) factor and an $\omega - f_0$ exchange degenerate Regge-pole model with trajectory $\alpha_\omega(t) = 0.4 + t$.

Fig. 3 shows excellent agreement with this relation using $\alpha(t) = 0.4 + t$ at 4.5 GeV/c. The dip in $\sigma_N^0(\rho)$ at $t \sim -0.4$ GeV/c^2 is thus explained from the signature zero of the ω trajectory when $\alpha_\omega(t) = 0$.

(iv) The α_{eff} values for $[\sigma_N^0(K^*) + \sigma_N^0(\bar{K}^*)]$ shown in fig. 5 are consistent with $\omega - f_0$ Regge pole trajectories near $0.5 + t$. The energy dependence of $\sigma_N^0(\rho)$ is also consistent with such an energy dependence although the errors are larger.

(v) The interference between the strong interaction amplitude and the one-photon exchange contribution has been observed [20] in the coherent production of K^* on nuclei. This allows the phase to be estimated and yields a predominantly real amplitude for K^* production. This agrees with the exchange-degenerate $\omega - f_0$ model which has a purely real amplitude for K^* production in-built from the duality constraint and absence of resonances in K-baryon quantum number channels. A predominantly imaginary amplitude would be expected for such an experiment performed with a K^- beam instead.

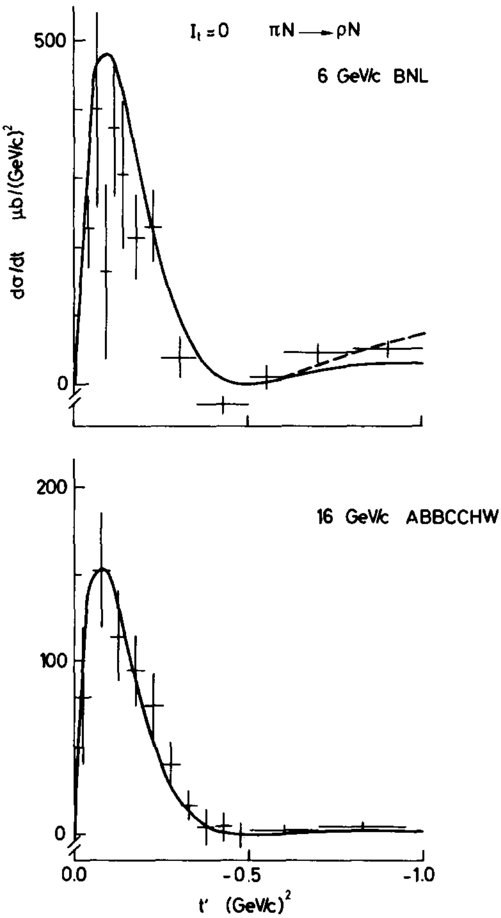

Fig. 4. Data [15] on the isoscalar exchange $\pi N \to \rho N$ differential cross sections at 6 and 16 GeV/c. The curves are from a simple Regge-pole expression [2] which is used to interpolate the data to 10 GeV/c.

(vi) The residue of a Regge pole is rather arbitrary function of t unless constrained by duality considerations. The simplest such constraint, the dual resonance model, gives a natural prescription for the residue function $\beta(t)$ and the associated scale of s. This leads, for an $n = 1$ amplitude of $\pm$ signature, to an amplitude

$$F^{\pm}(s,t) = A\,\Gamma(1-\alpha(t))\,(\mp 1 - \mathrm{e}^{-\mathrm{i}\pi\alpha(t)})\,(\alpha' s)^{\alpha(t)}\sqrt{-t}\,.$$

With exchange degenerate ω and f_0 poles, this leads to a t-dependence of $\sigma_N^0(K^*)$ and $\sigma_N^0(\bar{K}^*)$ of the form

$$-t\,\Gamma^2(1-\alpha(t))\,(\alpha' s)^{2\alpha(t)-2}\,,$$

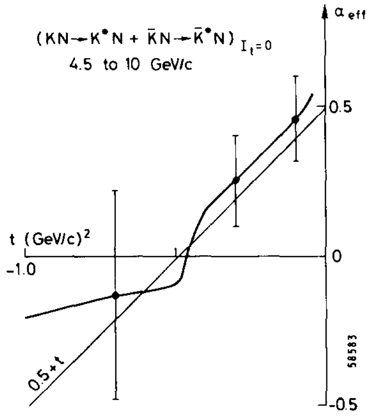

Fig. 5. The energy dependence at fixed t of the natural parity, isoscalar exchange component $[\sigma_N^0(K^*) + \sigma_N^0(\bar{K}^*)]$ is represented by $\alpha_{eff}(t)$. The data interpolations of fig. 1 give the α_{eff} curve shown together with typical errors at selected t-values. A simple Regge-pole expectation of $0.5 + t$ is also indicated.

and, with $\alpha(t) = 0.5 + t$ (or somewhat better $0.6 + t$) and $\alpha' = 1$ GeV^{-2}, this describes well the data at both 4.5 and 10 GeV/c.

4. Evidence for pomeron exchange

Within the errors, the simple $\omega - f_0$ exchange-degenerate Regge-pole approach can describe the $I_t = 0$ vector-meson production data. However, the pomeron P [defined here as a vacuum quantum number, natural-parity, positive-signature exchange contribution with an effective trajectory intercept $\alpha(0)$ near 1.0] can contribute to $KN \to K^*N$ and $\bar{K}N \to \bar{K}^*N$ in principle. Such a natural-parity exchange contribution must be in an helicity-flip amplitude; SU(3) singlet exchange does not contribute to a $K \to K^*_{888}$ transition, and any P-contribution must come from an SU(3) non-singlet component.The inequality of πN and KN high-energy total cross sections indicates that the P-contribution is not an exact SU(3) singlet.Such a helicity-flip, SU(3) non-singlet P-component might contribute to vector-meson production and would have the following consequences for the data.

(i) A direct effect on α_{eff} for $(\sigma_N^0(K^*) + \sigma_N^0(\bar{K}^*))$ which would lie above the $\omega - f_0$ Regge pole expectation of $0.5 + t$. The relative normalization of σ_N^0 from 4.5 to 10 GeV/c can be checked from the energy dependence of σ_U; σ_U falls faster than s^{-2} for the data of fig. 2. This could be due to inaccurate normalization or rather due to Reggeized π, B-exchange, absorption effects, etc., which all lead to a faster decrease than the s^{-2} expected for elementary π-exchange. The 14 GeV/c K^-p data [16] have a higher normalization than the 10 GeV/c and 16 GeV/c data [2,14].

Either of these two indications (fixing $\sigma_U \sim s^{-2}$ or taking account of the 14 GeV/c data) would tend to increase the α_{eff} values for σ_N^0 above the result of $0.55 + t$ presented in fig. 5.

(ii) Another consequence of a P-contribution would be in the comparison of $\sigma_N^0(K^*)$ with $\sigma_N^0(\bar{K}^*)$. The mainly imaginary P-contribution would interfere with the ω-exchange contribution to give $\sigma_N^0(\bar{K}^*) > \sigma_N^0(K^*)$ for $|t| < 0.4$, a cross-over at $t \sim -0.4$, and $\sigma_N^0(\bar{K}^*) < \sigma_N^0(K^*)$ beyond. Indeed, fig. 3 shows such an effect although the statistical and normalization errors are too large to draw a conclusion. It is interesting that such a splitting of K^* and $\bar{K}^*$ production at small t is opposite in sign to that found experimentally for other pairs of line reversed processes where the real process has the larger differential cross section (i.e., $K^+n \to K^0p$ relative to $K^-p \to \bar{K}^0n$).

(iii) The ratio of $\sigma_N^0(\rho)/(\sigma_N^0(K^*) + \sigma_N^0(\bar{K}^*))$ is influenced by the relative energy dependence of positive- and negative-signature exchange components. Choosing $\alpha_\omega = 0.4 + t$, this ratio can be understood (see fig. 3). Alternatively, requiring a trajectory $\alpha_\omega = 0.5 + t$, the $\sigma^0(\rho)$ data and SU(3) yield an exchange degenerate $\omega - f_0$ contribution to $[\sigma_N^0(K^*) + \sigma_N^0(\bar{K}^*)]$ which would contribute only about one half of the observed cross sections at small t.

These three features in the data are not sufficiently established because of the size of the errors. However, they all point to the conclusion that the positive-signature exchange component has a higher effective trajectory (e.g., $0.6+t$) than the negative-signature trajectory (e.g., $0.4+t$ to $0.5+t$). This can be interpreted as a breaking of the exchange degeneracy of the f_0 and ω trajectories, as found previously in Regge pole fits to elastic scattering. Such a violation of exchange degeneracy can be ascribed to mixing of the P with the f_0 trajectory. A direct P-contribution would also yield similar effects in the data by interfering with exchange degenerate ω and f_0 contributions. Within a limited energy range, and with presently available data, it is not possible to distinguish between a higher-lying f_0 trajectory on the one hand, and an f_0 trajectory of $0.5 + t$ accompanied by a small P-contribution on the other hand.

5. Isoscalar-isovector exchange interferences

A detailed discussion of such interference effects requires a knowledge of the properties of the isovector-exchange vector production amplitudes which are to be discussed in detail elsewhere [21]. A general introduction is possible, however, since the $I_t = 0$ exchanges, are predominantly in $n = 1$ amplitudes (helicity non-flip at the baryon vertex) while the $I_t = 1$ exchanges are predominantly in $n = 0$ or 2 amplitudes (helicity flip at the baryon vertex). Thus, there will be no interference terms in the differential cross section to a first approximation. The data of fig. 1, taken at face value, show at small t $\sigma_N(K^{*+}p) \sim \sigma_N(K^{*+}n)$, $\sigma_N(K^{*-}n) > \sigma_N(K^{*-}p)$ and $\sigma_N(\rho^+p) > \sigma_N(\rho^-p)$. Any such residual interference would require either an $I_t = 0$

helicity-flip coupling to baryons (e.g., the 10% amplitude found [1] in $\pi N \to \pi N$ at 6 GeV/c) or an $I_t = 1$ helicity non-flip coupling to baryons (e.g., the small ρ and A_2 couplings shown by σ_{tot} differences in πN and KN scattering). These effects can easily be arranged to reproduce the observed interference terms. Better experimental determinations of the relevant data ratios would be needed before such an analysis could be persued seriously.

6. Conclusions

The t-dependence, s-dependence and ratios of $I_t = 0$ vector meson production data are qualitatively described by a simple $\omega - f_0$ exchange degenerate Regge-pole approach incorporating SU(3). The unnatural-parity $I_t = 0$ production is negligible, consistent with the absence of any meson trajectories sufficiently high lying and with sufficient coupling.

An alternative approach [22] of requiring peripherality of the imaginary parts of exchange amplitudes leads to a behaviour like $J_1(R\sqrt{-t})$ with $R \sim 1$ fm. This results in a zero near $t = -0.6$ GeV/c and is consistent with the data and with the Regge approach. For this amplitude, the t-channel Regge approach satisfies the s-channel peripherality requirements, and such a happy amplitude may be expected to show little modification of the simplest Regge-pole expectations.

The data hint at a small violation of exchange degeneracy between the f_0 and ω This may be ascribed either to the direct presence of a small pomeron exchange component or to the direct mixing of such a component with the f_0 trajectory.

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