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POMERANCHON SU(3) ASSIGNMENT AND TOTAL CROSS SECTIONS*

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The present analysis stems from the following experimental facts:

(1) The total cross sections πN and KN seem to converge to different asymptotic values, the difference being of the order of 3 mb.[1]

(2) The total cross sections of πN and ρN are comparable, whereas ϕN is smaller by more than a factor of 2.[2]

(3) $\dfrac{\sigma(\gamma p \longrightarrow \phi p)}{\sigma(\gamma p \longrightarrow \rho p)}$ is smaller than the predicted SU(3) ratio by about a factor of 15;[3] this discrepancy comes in fact from (2) as suggested by the vector mesons dominance of the electromagnetic current.

These facts can be partially explained by SU(3) breaking: for example, the quark model[4] starts from (1) and explains (2) and (3).

In this letter the approach is different: SU(3) is assumed to be an exact symmetry for scattering amplitudes even at energies 10 ~ 20 GeV; the high energy behavior is given by exchanges in the t channel, the main contribution coming from the Pomeranchon of which we want to determine the SU(3) assignment.

We make the general assumption that the Pomeranchon is a linear superposition of a singlet and an octet states with a mixing angle α:

$$|P> = |P_1> \cos\alpha + |P_8> \sin\alpha$$

Consequently the contribution of P exchange to the forward elastic meson-nucleon scattering amplitudes is:

$$A_p^{\pi} = \left(\cos\alpha + \frac{1}{\sqrt{2}} \sin\alpha\right) A_p^{(0)}$$

$$A_p^{K} = \left(\cos\alpha - \frac{1}{2\sqrt{2}} \sin\alpha\right) A_p^{(0)}$$

$$A_p^{\rho} = A_p^{\omega} = \left(\cos\alpha + \frac{1}{\sqrt{2}} \sin\alpha\right) A_p^{(1)}$$

$$A_p^{\phi} = \left(\cos\alpha - \sqrt{2}\sin\alpha\right) A_p^{(1)}$$

where (0), (1) stands for 0^-, 1^- octets.

If we assume universality for the meson-meson-P coupling, we can derive the following conclusions that may be experimentally tested:

$$① \quad \lim_{s\to\infty} \left\{ \frac{\sigma_T(\pi p)}{\sigma_T(Kp)} \right\} = \frac{2\sqrt{2} + 2\tan\alpha}{2\sqrt{2} - \tan\alpha}$$

$$② \quad \lim_{s\to\infty} \left\{ \frac{\sigma_T(\pi p)}{\sigma_T(\rho p)} \right\} = 1$$

$$③ \quad \lim_{s\to\infty} \left\{ \sigma_T(\phi p) \right\} = \lim_{s\to\infty} \left\{ 2\,\sigma_T(Kp) - \sigma_T(\pi p) \right\}$$

Let us now consider a finite s; in addition to P, one can exchange the 2^+ $I = 0$ states f and f' (we consider only the t channel exchange of $I = 0$ C+ particles). In analogy with the 1^- octet, we suppose that f, f' are mixed with a mixing angle $A\tan\left(\frac{1}{\sqrt{2}}\right)$ as suggested by the quark model, in agreement with the mass formula and the production of f' in π and K -p interactions; this mixing angle and the hypothesis of universality of 2^+ mesons couplings leads to the property that f' does not couple to π and nucleons: it therefore does not contribute to any σ_T (meson-N).

The meson-nucleon scattering amplitudes can then be written ($I = 0$ C+ exchanges):

$$A_\pi = \left(\cos\alpha + \frac{1}{\sqrt{2}}\sin\alpha\right) A_p + A_f$$

$$A_K = \left(\cos\alpha - \frac{1}{2\sqrt{2}}\sin\alpha\right) A_p + \frac{1}{2} A_f$$

$$A_\rho = A_\omega = A_\pi$$

$$A_\phi = \left(\cos\alpha - \sqrt{2}\,\sin\alpha\right) A_p$$

so that

$$A_\phi = 2A_K - A_\pi \qquad (5)$$

or

$$④ \qquad \sigma_T\left(\phi_p\right) = 2\,\sigma_T\,(KN) - \sigma_T\,(\pi p)$$

where

$$4\,\sigma_T\,(KN) = \sigma_T\left(K^+p\right) + \sigma_T\left(K^-p\right) + \sigma_T\left(K^+n\right) + \sigma_T\left(K^-n\right)$$

$$2\,\sigma_T(\pi p) = \sigma_T\left(\pi^+p\right) + \sigma_T\left(\pi^-p\right)$$

We see that adding the assumptions of f - f' mixing angle and 2^+ universality has made our predictions ② and ③ valid for any s (high enough so that s channel contributions are negligible); for ③ , this fact is a pure accident since formula ③ is based only on P SU(3) assignment, and ④ on P and f SU(3) assignments.

In Fig. 1 our results are compared with the experimental data; the assumption of universality is in good agreement with the experiment since $\sigma_T(\rho p)$ is equal to $\sigma_T(\pi p)$ within the experimental error (even at the relatively low energy where $\sigma_T(\rho p)$ has been measured), while $\sigma_T(\phi p)$ seems to agree quite well with the combination $\left\{2\,\sigma_T\,(KN) - \sigma_T(\pi p)\right\}$ which is shown to be constant with energy. Figure 1 also shows the prediction of the quark model for $\sigma_T\,(\phi p)$ which should increase with energy (in this latter case the errors are smaller since the model involves only $K^{\pm}p$ cross sections and not the less accurate $K^{\pm}n$ cross sections).[6]

A sufficiently accurate measurement of $\sigma_T(\phi p)$ in function of energy could choose between unbroken or broken SU(3) scattering theory; but experimentally this seems very difficult. Another important test would be to measure accurately the $K^{\pm}$-proton and neutron cross sections.

To make quantitative predictions, one should assume an asymptotic behavior: using the Regge poles model, we can fit the experimental data on $\sigma_T(\pi p)$, $\sigma_T(KN)$ and the real part of the (πp) elastic amplitude. In the familiar notation:

$$\sigma_T(\pi p) = A_p^{\pi} + A_f \left(\frac{E}{E_0}\right)^{\alpha_f - 1}$$

$$\sigma_T(KN) = A_p^{K} + \frac{1}{2} A_f \left(\frac{E}{E_0}\right)^{\alpha_f - 1}$$

$$\left[\frac{\mathrm{Re}\,(\pi p)}{\mathrm{Im}\,(\pi p)}\right]_{t=0} = \frac{-A_f \left(\frac{E}{E_0}\right)^{\alpha_f - 1}}{\left[A_p + A_f \left(\frac{E}{E_0}\right)^{\alpha_f - 1}\right] \tan \frac{\pi \alpha_f}{2}}$$

$$E_0 = 1 \text{ GeV}$$

The results of the fitting are shown in Fig. 2 and Table I. We present two fits: In fit 1, α is taken equal to 0 (P unitary singlet) and the 3 parameters A_p, A_f, α_f are deduced; fit 2 investigates the possibility of (P_1, P_8) mixing by fitting 4 parameters: A_p^{π}, A_p^{K}, A_f, α_f. The results strongly favor different asymptotic limits for $\sigma_T(\pi p)$ and $\sigma_T(KN)$ with a mixing angle $\alpha = (10.5 \pm 2.0)^\circ$. Obviously this value is dependent on the assumed Regge asymptotic behavior.

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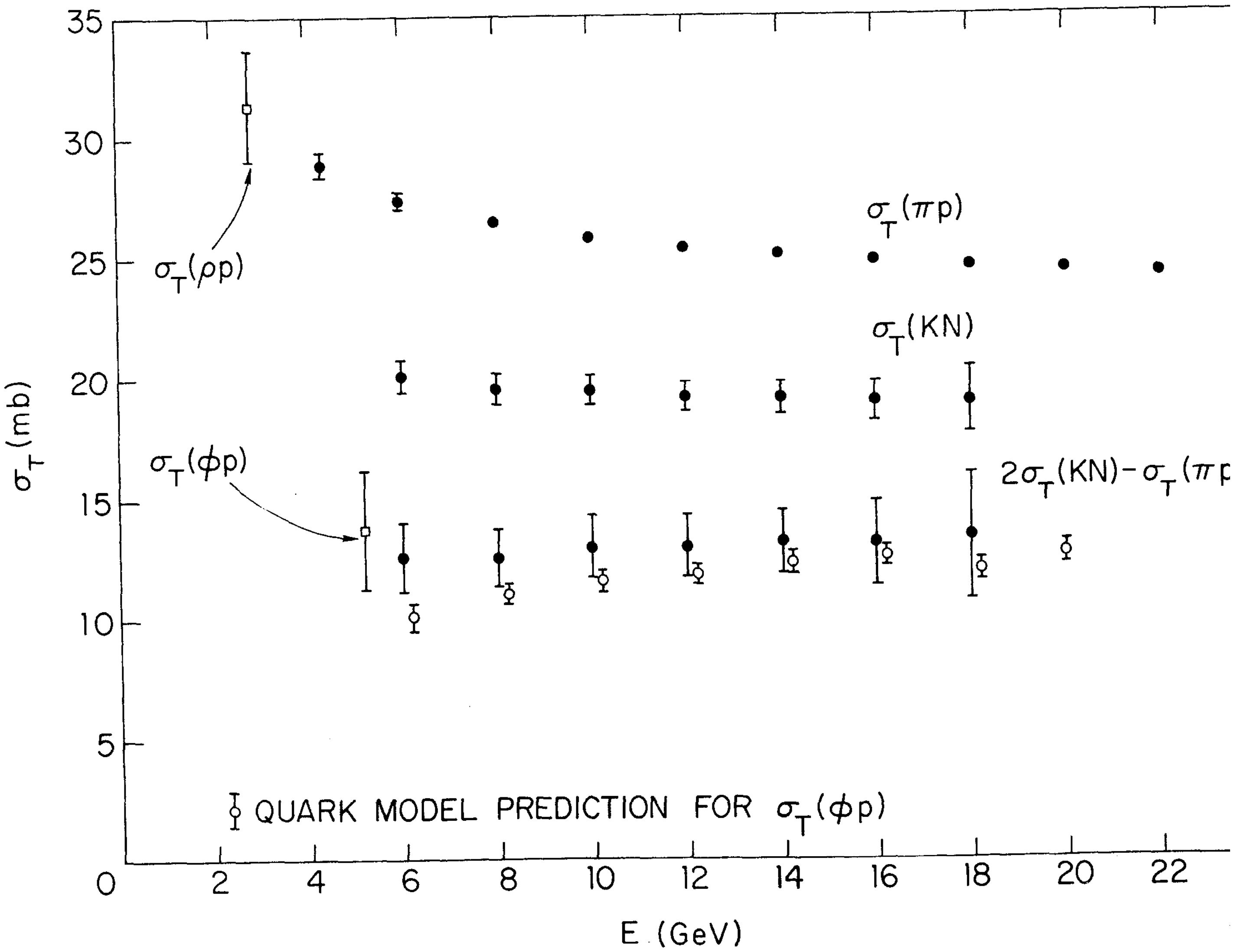
TABLE I

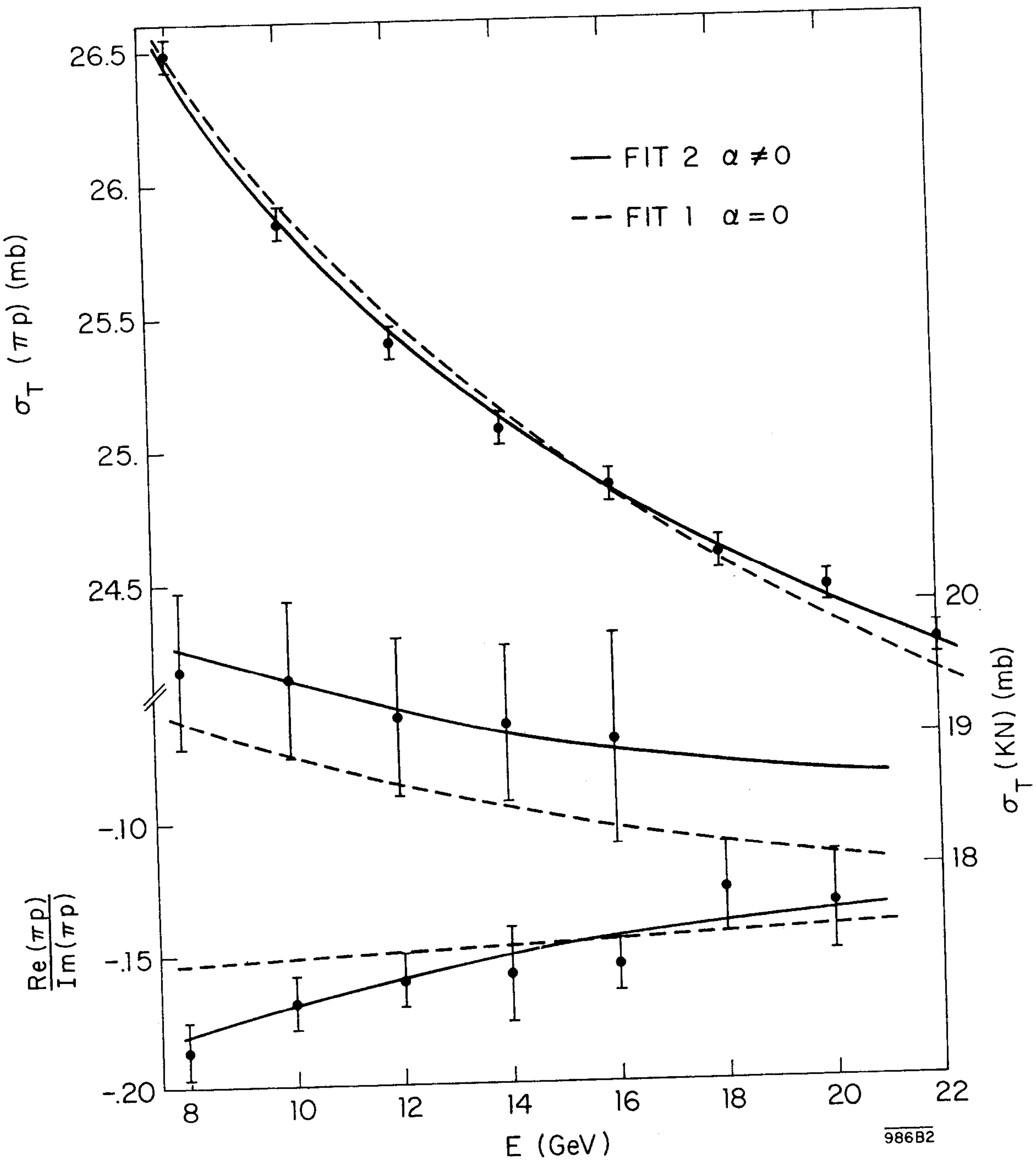
The experimental data used in these fits are: $\sigma_T(\pi p)$ from 8 to 22 GeV by Foley et al.[1]; $\sigma_T(KN)$ from 8 to 18 GeV by Galbraith et al.[1]; Re (πp) from 8 to 20 GeV by Foley et al.[7]

	A_p^{π} (mb)	A_p^{K} (mb)	α (d°)	A_f (mb)	α_f	χ^2
Fit 1 $\alpha = 0$	11.8 ± .5	11.8 ± .5	0	21.0 ± .4	.83 ± .01	31.7 DF = 18
Fit 2 $\alpha \neq 0$	19.8 ± .4	16.4 ± .4	10.5 ± 2.0	15.1 ± .5	.60 ± .02	5.9 DF = 17



35
30
25
20
15
10
5
0
2
4
6
8
10
12
14
16
18
20
22
σ_T (mb)
E (GeV)
$\sigma_T(\rho p)$
$\sigma_T(\phi p)$
$\sigma_T(\pi p)$
$\sigma_T(KN)$
$2\sigma_T(KN)-\sigma_T(\pi p$
QUARK MODEL PREDICTION FOR $\sigma_T(\phi p)$

Fig. 1



FIT 2 α ≠0
FIT 1 α = 0
26.5
26.
25.5
25.
24.5
-.10
-.15
-.20
σT (πp) (mb)
Re(πp)/Im(πp)
20
19
18
σT (KN) (mb)
8
10
12
14
16
18
20
22
E (GeV)
986B2

Fig. 2