locus for this single zero which almost completely removes the discrepancy in ϕ_+, and to a somewhat lesser extent in ϕ_-, across the partial-wave region is consistent with there being only one. Nevertheless, the behavior of the zeros at nonforward angles is an assumption and is apt to be more troublesome as the calculation is extended to larger t. Presently, we are working on ways of handling this difficulty.

The method is, of course, limited by the available experimental input and, as noted in Sec. V, the comparison of ϕ_- from the partial waves and forward dispersion relations raises some question about the $\pi^- p$ data. Our results could be affected either through errors in $|A'_-|$ or in the subtraction-point phase $\phi_-(\nu_0, t)$. Another limitation for high-energy applications comes from the asymptotic region. The integrals in the LDR depend strongly on the value of $|A'|$ in the neighborhood of the principal-value point, and the higher the energy the more critical is the assumed behavior of $|A'|$. A modification of the function F as given by Eq. (10), which will lessen the dependence of this region while retaining the virtues of the subtraction, is being sought.

In the immediate future we plan to extend this calculation to $-t=0.40$ $(\text{GeV}/c)^2$ and later to make applications of the LDR to Kp scattering and to πN polarization.

*Based in part on a M. S. thesis submitted by L. E. Pitts to Georgetown University.

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Nonleptonic Hyperon Decays in a Current-Current Quark Model*

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The symmetric quark model is used to provide an explanation of the S- and P-wave nonleptonic hyperon decays. The current-algebra approach, applied to the current-current weak Hamiltonian constructed of Bose-type quark fields, leads to a remarkable agreement with experiment.

I. INTRODUCTION

The universal current-current theory of the weak interactions[1] has been successful in describing the leptonic and semileptonic weak processes. However, attempts made to apply the theory to the nonleptonic decays led to considerable disagreement with observations.[2] It appears as if the application of symmetry principles such as SU(3) and CP invariance and the assumptions of current algebra and partial conservation of axial-vector current (PCAC) cannot always explain the empirical $|\Delta I| = \frac{1}{2}$ rule observed in all these processes. Moreover, even when octet dominance is assumed, direct application of soft-pion techniques to the nonleptonic hyperon decays leaves us with the wrong ratio of P- to S-wave amplitudes.[3]

It is believed in general that with the above assumptions one can fairly well describe the main features of S-wave amplitudes, while the P waves cannot be understood through similar techniques since they involve some delicate limiting procedures. It should be realized, however, that even for the S waves all we could get by the soft-pion approximation was a three-parameter fit for the seven amplitudes.[4] The octet rule could not be predicted; the relations obtained were consistent with a $|\Delta I|=\frac{1}{2}$ rule but not equivalent to it.

Judging from the rather meager results obtained by applying current-algebra techniques to the nonleptonic hyperon decays, it seems desirable to supplement the conventional assumptions by some other hypothesis in order to make the description of these processes more comprehensive.

In the present paper we shall use an assumption which has recently been adopted[5] in order to attribute the octet-dominance property to the hadronic weak Hamiltonian. We shall assume that the hadronic current is made up of Bose-type quarks. The SU(3)×SU(3) current algebra is obviously preserved when assuming canonical commutation relations for the quark fields instead of the conventional anticommutation relations. As our second assumption we shall identify the quarks in the currents with the constituents of the hadrons. The latter ones can be bosons if, for example, each baryon contains a spinless fermion (the "soul"[6] of a baryon) in addition to the three quarks. The assignment of Bose statistics to the constituent quarks seems to be very strongly suggested by the success of the symmetric quark model in hadron spectroscopy.[7]

We would like to mention that while our first assumption only yields a particular *symmetry* property for the weak-Hamiltonian operator, our second hypothesis will enable us to evaluate *matrix elements* of this operator between single-particle states. This resembles the situation in the deep-inelastic lepton scattering, where it has been recently very fashionable to augment the general hypothesis of light-cone *algebra* (abstracted from the free-quark model) with particular assumptions about the constituents of hadrons ("partons"); the latter being in fact assumptions about *matrix elements* of the expansion operators on the light cone.[8]

In the framework of the suggested Bose-quark model we shall study the hyperon decays using current-algebra analysis. In addition to the hypothesis of current algebra and PCAC we will invoke CP invariance and SU(3) symmetry. Our model will eliminate some of the difficulties which one faced when applying the soft-pion approximation to the hyperon decays.

In Sec. II we describe the current-current quark model, and determine in its framework some relevant single-particle matrix elements.

In Sec. III both S- and P-wave amplitudes are studied through current-algebra techniques in a manner similar to some other previous works.[3,4] We discuss the agreement between our model and experiment.

Section IV concludes our results and describes the predictive power of our approach for Ω decays.

II. THE QUARK MODEL FOR THE WEAK HAMILTONIAN

The nonleptonic weak-Hamiltonian density, which is that part of the universal weak interaction responsible for the pure hadronic processes, has the following form:

$$\mathcal{H}(x)=\frac{G}{\sqrt{2}}:\{J_\mu(x),J^\mu(x)\}:, \tag{1}$$

where J_μ is the familiar Cabibbo current,

$$J_\mu(x)=\bar\psi(x)\gamma_\mu(1+\gamma_5)[\cos\theta(\lambda_1+i\lambda_2)+\sin\theta(\lambda_4+i\lambda_5)]\psi(x). \tag{2}$$

$\psi(x)$ represents the multicomponent Bose-quark field operator, and the λ_i stand for the 3×3 SU(3) matrices.

The interference term in Eq. (1) is the one which causes the hyperon decays,

$$\mathcal{H}(\Delta S=1)=\frac{G}{\sqrt{2}}\cos\theta\sin\theta\,\lambda_{jl}^{ik}:\{J_{\mu i}^{j},J_{k}^{\mu l}\}:, \tag{3}$$

where

$$\lambda_{jl}^{ik}=(\lambda_1-i\lambda_2)_j^i(\lambda_4+i\lambda_5)_l^k,$$

$$J_{\mu i}^{j}=\bar\psi_i\gamma_\mu(1+\gamma_5)\psi_j.$$

$i(j,k,l)$ is the triplet representation index of SU(3). From the properties of the Fierz transformation and the assumed bosonic character of the quark fields it follows that the operator $\{J_{\mu i}^{j}, J_{k}^{\mu l}\}$ is antisymmetric under the interchange of each of the two pairs of SU(3) indices,

$$i\leftrightarrow k,\quad j\leftrightarrow l.$$

It is clear, therefore, that this operator represents an octet.[5] (Since our operator changes strangeness, the singlet is excluded.)

It is worthwhile mentioning two peculiar features of the operator $\mathcal{H}$:

(a) It describes an interaction between four quarks at one point.

(b) It creates (annihilates) two quarks in (from) a state which is antisymmetric under the interchange of their triplet indices. These properties and the identification of the above described quarks with the constituents of hadrons allow the prediction of the single ground-state baryon matrix elements of the Hamiltonian

$$H(0)=\int\mathcal{H}(0,\vec{x})d^3x.$$

To study the single octet baryon matrix elements, we recall that within the framework of SU(3) symmetry, CP invariance, and the current-current theory there are no parity-violating transitions between two baryons,[9]

$$\langle B_8 | H^{\text{p.v.}} | B_8 \rangle = 0 . \tag{4}$$

On the other hand, the parity-conserving matrix element can be parametrized by virtue of the octet property as[10]

$$\langle B_j | H^{\text{p.c.}} | B_i \rangle = 2\sqrt{2}\, \bar{u}_j (i f_{6ij} F + d_{6ij} D) u_i . \tag{5}$$

The ratio F/D is an essential parameter in any current-algebra treatment of the nonleptonic hyperon decays.[3,4] Let us evaluate it in the framework of our model. Consider the transition between Ξ^0 and Σ^0,

$$\langle \Sigma^0 | H^{\text{p.c.}} | \Xi^0 \rangle = -\bar{u}_\Sigma (F + D) u_\Xi .$$

This matrix element gets contributions only from the quark operator $:\{J^s_{\mu u},\ J^{\mu u}_d\}:$, where the upper quarks (s, u) act on Ξ^0, while the lower nonstrange quarks (u, d) act on Σ^0. The third quark s in both states remains untouched by the interaction. Since the Σ^0 state is symmetric in SU(3) under the interchange $u \leftrightarrow d$ while the weak Hamiltonian is antisymmetric under this interchange, we conclude that

$$\langle \Sigma^0 | H^{\text{p.c.}} | \Xi^0 \rangle = 0 ,$$

and therefore $F/D = -1$ for the octet baryon matrix elements of H.

All other matrix elements of H between the ground states ($\underline{56}$, $L^P = 0^+$) vanish identically. In fact,

$$\langle B_{10} | H | B \rangle = \langle B | H | B_{10} \rangle = 0 , \tag{6}$$

where B is any single-baryon state. This is a consequence of property (b) and the fact that the states in the decuplet are fully symmetric in SU(3) under permutations of the three quarks. Since two quarks moving in a (radially) excited state interact at a point weaker than in the $(L = 0)$ ground state, we shall use (a) to assume

$$| \langle B^* | H | B_g \rangle | \ll | \langle B_g | H | B_g \rangle | , \tag{7}$$

where B_g is the octet part of the quark-model baryonic ground state ($\underline{56}$, 0^+) and B^* is any excited state in the quark model.

A similar assumption will be made for the mesonic matrix elements,

$$| \langle M^* | H | M_g \rangle | \ll | \langle M_g | H | M_g \rangle | . \tag{8}$$

Namely, matrix elements of H between a ground state ($\underline{36}$, 0^-) and any excited state are suppressed relative to matrix elements between two ground states.

III. S- AND P- WAVE HYPERON DECAYS IN THE SOFT-PION APPROXIMATION

The physical amplitude for the baryon B_j with momentum p to decay into a baryon B_k with momentum p' and a pion π_i with momentum q is given by

$$\begin{aligned} T^{ijk}(q^2 = m_\pi^2) &\equiv (2q_0)^{1/2} \langle B_k(p') \pi_i(q) | H(0) | B_j(p) \rangle \\ &= \bar{u}(p') (A^{ijk} + B^{ijk} \gamma_5) u(p) , \end{aligned} \tag{9}$$

where A and B are the S- and P-wave amplitudes, respectively. By the Lehmann-Symanzik-Zimmermann reduction technique and a partial integration, we may relate T to the off-mass-shell decay amplitude,

$$\begin{aligned} T^{ijk}(q) = (q^2 - m_\pi^2) \int d^4x\, e^{-iq\cdot x} \\ \times \langle B_k | [\pi_i(x),\ H(0)] | B_j \rangle \theta(x_0) . \end{aligned} \tag{10}$$

$\pi_i(x)$ is the off-mass-shell pion field related to the axial-vector current by PCAC,

$$\partial_\mu A^\mu_i(x) = \frac{f_\pi}{\sqrt{2}} m_\pi^2 \pi_i(x) ,$$

where

$$f_\pi = \frac{g_A m_N \sqrt{2}}{g_{\pi NN} K(0)} = 0.95 m_\pi .$$

Therefore, one obtains

$$\begin{aligned} T^{ijk}(q = 0) = &-\frac{\sqrt{2}}{f_\pi} \langle B_k | [F^5_i(0),\ H(0)] | B_j \rangle \\ &+ \frac{\sqrt{2}}{f_\pi} \lim_{q \to 0} q^\mu M^{ijk}_\mu , \end{aligned} \tag{11}$$

where

$$M^{ijk}_\mu = \int d^4x\, e^{-iq\cdot x} \langle B_k | [A_{\mu i}(x),\ H(0)] | B_j \rangle \theta(x_0) ,$$

$$F^5_i(0) = \int d^3x\, A_{0i}(0,\ \vec{x}) .$$

The second term in Eq. (11) gets contributions only from intermediate octet baryon states.

In order to avoid ambiguity in taking limits when applying the soft-pion approximation to the hadronic hyperon decays,[3] the usual procedure has been to rewrite the amplitude in the form

$$T^{ijk}(q) = B^{ijk}(q) + R^{ijk}(q) ,$$

where $B^{ijk}(q)$ is the baryon pole term.

From Eq. (11) we find

$$\begin{aligned} R^{ijk}(q = 0) = &-\frac{\sqrt{2}}{f_\pi} \langle B_k | [F^5_i(0),\ H(0)] | B_j \rangle \\ &+ \lim_{q \to 0} \left[\frac{\sqrt{2}}{f_\pi} q^\mu M^{ijk}_\mu - B^{ijk}(q) \right] . \end{aligned} \tag{12}$$

The usual soft-pion approximation would then be to assume that $R(q)$ is a slowly varying function of q so that $R(q^2=m_\pi^2)\simeq R(q=0)$.

In the quark model this seems reasonable except for one case, namely, the contribution of the K^* pole.[11] Other meson-resonance terms and the baryon-resonance terms are suppressed relative to the pole terms in our model [Eqs. (6)–(8)], and the pseudoscalar (K) terms are insensitive to the soft-pion limit. The K^* term, on the other hand, vanishes in this limit, while for a physical pion it can give a considerable contribution.

Hence one finds (with K^{*ijk} being the K^*-pole contribution)

$$T^{ijk}(q^2=m_\pi^2) \simeq -\frac{\sqrt{2}}{f_\pi}\langle B_k|[F_i^5(0),\ H(0)]|B_j\rangle + K^{*ijk}(q^2=m_\pi^2) + B^{ijk}(q^2=m_\pi^2) + \lim_{q\to 0}\left[\frac{\sqrt{2}}{f_\pi}q^\mu M_\mu^{ijk} - B^{ijk}(q)\right]. \tag{13}$$

We choose to adopt the very common point of view that SU(3) is conserved at vertices and broken in the hadron masses to account for their actual values.

With this prescription for SU(3) symmetry and the CP invariance one observes that the first term in Eq. (13) contributes merely to the S waves, while the two last terms produce the P waves.[3] The K^* contribution to the S waves survives merely because of SU(3) breaking in the baryon masses.[9] In order to estimate the absolute magnitude of this contribution, we shall assume that the vector-meson pole describes the $K\to 2\pi$ amplitude as well.[12,13] The F-type K^*BB coupling is assumed to be given by the universal coupling of K^* to the strangeness-changing current.[14] One finds

$$K^{*ijk} = c d_{i6l}\left(if_{lkj} + \frac{\delta}{\phi} d_{lkj}\right)(m_j - m_k)\bar{u}(p')u(p), \tag{14}$$

where δ/ϕ is the D/F ratio for the γ_μ coupling at the strong VBB vertex.

The constant c is obtained from the measured $K_S^0\to\pi^+\pi^-$ decay width,

$$c = 3.2\times 10^{-9}\ \mathrm{MeV}^{-1}. \tag{15}$$

Using the SU(3)×SU(3) current algebra we can express the first term in Eq. (13) in terms of the matrix elements (5). The last two terms in Eq. (13) may be explicitly evaluated with an SU(3)-symmetric π-meson–baryon vertex and the generalized Goldberger-Treiman relation

$$f_\pi = \frac{g_A^{ijk}(m_j+m_k)\sqrt{2}}{g_{ijk}K(0)}. \tag{16}$$

Finally one obtains the following expressions for the S and P waves:

$$\begin{aligned}
A(\Sigma_-^-) &= (\sqrt{2}/f_\pi)(-D+F) - \tfrac{1}{4}c\sqrt{2}(\Sigma - N)(1-\delta/\phi),\\
A(\Sigma_+^+) &= 0,\\
A(\Sigma_0^+) &= f_\pi^{-1}(D-F) + \tfrac{1}{4}c(\Sigma - N)(1-\delta/\phi),\\
A(\Lambda_-^0) &= (\sqrt{3}f_\pi)^{-1}(D+3F) - \tfrac{1}{4}c\sqrt{3}(\Lambda - N)[1+\tfrac{1}{3}(\delta/\phi)],\\
A(\Xi_-^-) &= (\sqrt{3}f_\pi)^{-1}(D-3F) + \tfrac{1}{4}c\sqrt{3}(\Xi - \Lambda)[1-\tfrac{1}{3}(\delta/\phi)],\\
B(\Sigma_-^-) &= 2g(N+\Sigma)\left(\frac{f(F-D)}{(\Sigma-N)2\Sigma} - \frac{d(3F+D)}{3(\Lambda-N)(\Sigma+\Lambda)}\right),\\
B(\Sigma_+^+) &= 2g(N+\Sigma)\left(\frac{(f+d)(F-D)}{(\Sigma-N)2N} - \frac{f(F-D)}{(\Sigma-N)2\Sigma} - \frac{d(3F+D)}{3(\Lambda-N)(\Sigma+\Lambda)}\right),\\
B(\Sigma_0^+) &= \sqrt{2}g(N+\Sigma)\left(\frac{(f+d)(F-D)}{(\Sigma-N)2N} - \frac{2f(F-D)}{(\Sigma-N)2\Sigma}\right),\\
B(\Lambda_-^0) &= \left(\frac{2}{3}\right)^{1/2} g(\Lambda+N)\left(\frac{(f+d)(3F+D)}{(\Lambda-N)2N} - \frac{2d(F-D)}{(\Sigma-N)(\Sigma+\Lambda)}\right),\\
B(\Xi_-^-) &= \left(\frac{2}{3}\right)^{1/2} g(\Xi+\Lambda)\left(-\frac{2d(F+D)}{(\Xi-\Sigma)(\Sigma+\Lambda)} - \frac{(d-f)(3F-D)}{(\Xi-\Lambda)2\Xi}\right).
\end{aligned} \tag{17}$$

In the above equations the particle symbols denote the corresponding physical masses, g is the strong pion-nucleon coupling $g^2/4\pi = 14.6$, and f and d are the symmetric and antisymmetric MBB couplings, respectively ($f+d=1$). The ten S- and P-wave amplitudes[15] are given in terms of the four parameters F, D, f, δ/ϕ.

The best fit to the experimental amplitudes[16] is obtained with the following values:

$$\begin{aligned} F &= 4.7\times 10^{-5}\ \mathrm{MeV}\,, \\ D/F &= -0.85\,, \\ d/f &= 1.8\,, \\ \delta/\phi &= -0.5\,. \end{aligned} \tag{18}$$

The results of the best fit are compared with experiment in Table I. The fit seems remarkable when compared with previous works.[3]

A relevant question is, obviously, to what extent are the values obtained in Eq. (18) reasonable in the framework of our assumptions? The ratio D/F differs only by 15% from the value (−1) predicted in Sec. II. In view of the fact that we neglected possible SU(3)-breaking effects at the strong vertices, this deviation is not unexpected.[17] Some discussions of SU(3)-symmetry breaking indicate that these effects may be enhanced in the P waves.[17] The correlation between the D/F value and the P-wave amplitudes is stronger than the one with the S-wave amplitudes (the latter being strongly dependent on the δ/ϕ ratio, while the former are rather insensitive to the d/f value). Neglecting the symmetry-breaking terms may, therefore, cause the observed deviation.

The strong d/f ratio coincides within the same accuracy (20%) with the quark-model value[7] ($d/f = 1.5$) and with the latest best-fit value obtained from measurements of the axial-vector matrix elements in the semileptonic decays of baryons.[18]

We have obviously no direct experimental information about the δ/ϕ ratio for the VBB vertex. However, from Regge-type analysis of meson-baryon scattering and K^+ photoproduction one obtains values which are not inconsistent with our ratio.[19] The vector-meson-dominance model would predict $\delta/\phi = 0$.

The fourth parameter in our analysis, F, which measures the absolute magnitude of the decay amplitudes, is not easily evaluated in an independent way. Attempts made to saturate the current-current Hamiltonian by the lowest-lying intermediate states between the currents led to some estimates in the neighborhood of our value for F.[20]

We have included in Table I also the "symmetry" values for the amplitudes which were obtained with $D/F = -1$ and $d/f = 1.5$. These values seem to provide a nice discription of the S and P waves except for $A(\Lambda^0_-)$ and $B(\Sigma^-_-)$.

IV. CONCLUDING DISCUSSION

In this paper we have investigated the theoretical possibility that the current-carrying spin-$\frac{1}{2}$ elements of the weak hadronic interaction coincide with the constituents of hadrons and obey symmetrical statistics. Using current-algebra techniques we found a remarkable simultaneous fit to the S- and P-wave amplitudes. The results of our fit seem to be consistent with our basic assumptions. Our prediction $D/F \approx -1$ is in obvious disagreement with a previous result[4] which assigned the value −0.3 to this ratio. Previous works, however, generally assumed that the soft-pion approximation in its simplest version[21] should work for the S-wave amplitudes while being questionable for the P-wave amplitudes. Our model, in which some knowledge is available about higher (resonance) intermediate-state contributions to the amplitudes, avoids this doubtful assumption. It is worth mentioning in this connection that with the value $D/F \simeq -0.3$, which is remarkably close to the medium-strong D/F ratio, one would find[22] in the baryon-pole approximation $B(\Sigma^+_+) = 0$, in contradiction with experiment. Moreover, speculative attempts[23] to assume that the parity-conserving hadronic weak Hamiltonian and the medium-strong Hamiltonian belong to the same octet led to the vanishing of the P-wave amplitudes in the SU(3)-symmetric limit.[24] With our different value for D/F we avoid these difficulties.

The model presented in this paper predicts also those nonleptonic decay amplitudes of the Ω^- particle, in which a pion is emitted. By applying the

TABLE I. Best-fit solution to S- and P-wave amplitudes. (All amplitudes are given in units of $10^5\ m_\pi^{-1/2}\,\mathrm{sec}^{-1/2}$.)

	A			B		
Decay process	Best fit	"Symmetry"	Experiment	Best fit	"Symmetry"	Experiment
Σ^-_-	2.1	2.3	1.89 ± 0.03	−0.4	4.0	-0.72 ± 0.01
Σ^+_+	0	0	0.06 ± 0.02	20.3	22.2	19.07 ± 0.34
Σ^+_0	−1.5	−1.6	-1.53 ± 0.14	14.6	12.9	11.52 ± 1.85
Λ^0_-	1.2	0.9	1.53 ± 0.02	11.6	9.0	10.50 ± 0.33
Ξ^-_-	−2.0	−2.0	-2.07 ± 0.02	7.7	8.1	6.68 ± 0.70

soft-pion approximation developed in the previous section to the processes $\Omega^- \rightarrow \Xi^-\pi^0$ ($\Xi^0\pi^-$) one can estimate their decay width. Since the P-wave amplitudes are given by the baryon-pole term, they will vanish by virtue of Eq. (6).[25] On the other hand, the D-wave amplitudes are given merely by the K^* term. Using a previous calculation of these amplitudes in a K^*-pole model[26] we find, with our value of c given in Eq. (15),

$$\Gamma(\Omega_0^-) = \tfrac{1}{2}\Gamma(\Omega_-^-) \gtrsim 10^8 \text{ sec}^{-1}.$$

The total number of $\Omega \rightarrow \Xi\pi$ events[16] is only 11 and the partial decay widths are still unreliable.

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Reggeized Multiple-Scattering Quark Model of Kaon-Nucleon Scattering*

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The Reggeized multiple-scattering quark model, which correctly predicted the flattening of pion-nucleon total cross sections subsequently observed at Serpukhov, is applied to the kaon-nucleon system. A good fit to all available $K^{\pm}$-nucleon elastic and charge-exchange data is obtained using the Pomeranchuk trajectory and exchange-degenerate P'-ω and ρ-A_2 trajectory pairs. The multiple-scattering terms produce subtractive Regge-cut effects which, disappearing as $(\ln s)^{-1}$, permit the total cross sections to rise very slowly toward an asymptote of $\sigma_\infty = 26.0 \pm 0.5$ mb. Predictions for these reactions up to 10 000 GeV/c are given.

In an earlier paper[1] we formulated a model for pion-nucleon scattering involving the use of Regge-pole amplitudes for the scattering from an individual quark, with Regge-cut effects generated from multiple-scattering terms calculated via the Glauber theory. A good fit was obtained to all available varieties of experimental data, and it was predicted that the vanishing of the subtractive Regge-cut effects would cause total cross sections to level off, then rise very slowly toward an asymptotic value of 25.66 mb. Subsequent measurements obtained at Serpukhov[2] were in excellent quantitative agreement with this prediction.[3]

Prompted by this success and by the increasing amount of relevant data now available, we have applied a similar model to kaon-nucleon interactions. The formulation of the amplitude is essentially identical to that of I. The scattering of a kaon by one of the nucleon quarks, with momentum transfer $\vec{\Delta}$, is described by

$$f_i(\vec{\Delta}) = f_{00}(\vec{\Delta}) + f_{01}(\vec{\Delta})\vec{K}\cdot\vec{\tau}_i + f_{10}(\vec{\Delta})\vec{n}\cdot\vec{\sigma}_i + f_{11}(\vec{\Delta})\vec{n}\cdot\vec{\sigma}_i\vec{K}\cdot\vec{\tau}_i\,, \tag{1}$$

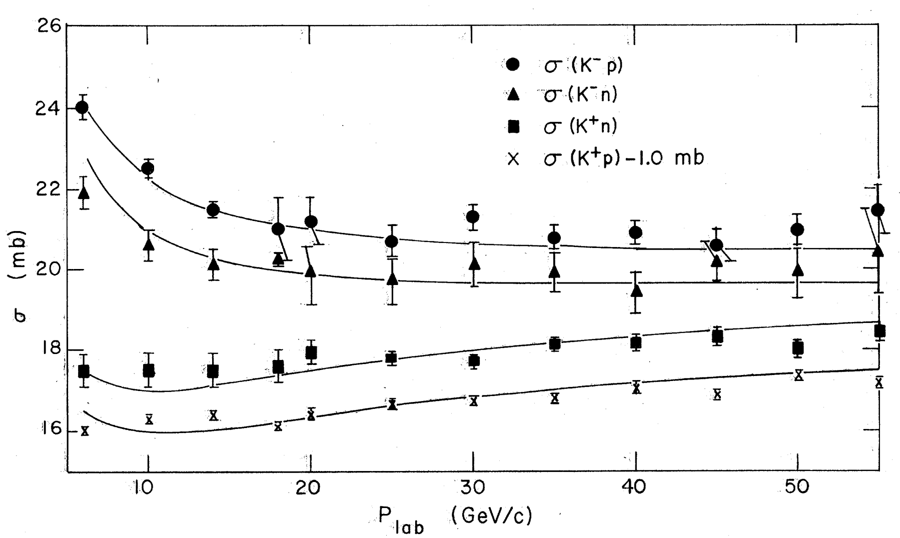

FIG. 1. Comparison of our fits with the total cross sections. The K^+p data and curve have been lowered by 1 mb for clarity.