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THE INFLUENCE OF K* AND PION RESONANCES AND HYPERON PARITIES ON K-NUCLEON SCATTERING†

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ABSTRACT. K-nucleon scattering is assumed to be due to the set of processes shown in Fig. 1, in which intermediate states consisting of the vector meson resonances play important roles. These processes are evaluated using straightforward perturbation methods. Comparing the results with the experimental data available for both I = 1 and I = 0 isotopic spin states, it is found that the only combination of parities of hyperons for which agreement with experiment is possible is that given by $P(\Lambda KN) = P(\Sigma KN) = -1$, the coupling constants being $g_\Lambda^2 \simeq 5$ and $g_\Sigma^2 \simeq 2.3$. The two-pion isovector resonance is found to give negligible contribution to the scattering, while the exchange of the three-pion isoscalar resonance plays an important role. The contributions of the fourth order diagrams involving the K* resonance to the scattering in both isotopic spin states are strong and attractive.

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Introduction.

Experimental results on the K^+p interaction at medium energies show a remarkable isotropy in the angular distribution for incident mesons of 225 and 455 Mev kinetic energies in lab system (Ref.1,2). The total $K^+p \rightarrow K^+p$ cross section has been obtained at 175, 225, 275 and 455 Mev (Ref. 1, 2). The experimental points are those indicated in Fig. 9. The observed interference with the coulomb interaction indicates the K^+p interaction to be repulsive. On the other hand, analysis of the K^+-deuterium experiments (Ref. 3,4) has shown that the experimental results can be explained by S-wave interactions in both I = 1 and I = 0 isotopic spin states. The analysis shows that the signs of the amplitudes in the two isospin states are opposite, the I = 0 interaction being then attractive. The analysis of these K^+d experiments provides the way to determine, from the $K^+d \rightarrow K^0pp$ cross section, the value of the cross section for the corresponding free neutron process $K^+n \rightarrow K^0p$. The results are shown by the points indicated in Fig. 10.

Attempts to explain the main features of the K^+-p elastic interaction have been made, but none is quite complete. The data we now have on the interaction in the I = 0 state should be included and explained by any model which aims to be consistent with all available data. The contributions due to the coupling through the hyperon fields have been studied by perturbation methods (Ref. 5,6). These terms alone cannot give a fair explanation of the data, and no other simple graphs could be added and evaluated to improve the situation.

The discovery of new resonances (which we shall call vector mesons) involving pions and kaons may throw some light in this problem. The K*-meson (the I = 1, J = 1 resonance in the K-π system) may affect strongly the K-nucleon processes. A K* resonance can be formed between the incident K and the pions of the nucleon cloud. Also, the ρ-meson (the I = 1, J = 1 two pion resonance) and the ω-meson (the I = 0, J = 1 three-pion resonance) interact strongly with the nucleon field (Ref. 7,8); if the K-meson charge current also has large contributions coming from these pions states, the exchange of two or three resonating pions between the K-meson and the nucleon might play an important role in K-nucleon scattering. Dispersion relations techniques have been used to estimate separately some of these effects. The energy dependence of the S-wave phase-shift for K-nucleon scattering has been estimated by B. W. Lee (Ref. 9) in a model in which a phenomenological zero range force and the long range forces due to the exchange of a vector meson with isotopic spin I = 1 give the only contribution to the scattering. The results, after adjusting parameters to fit the data, are that the long range part of the interaction comes out to be attractive in the I = 1 state and repulsive in the I = 0 state. The effect of the existence of the K* resonance on the low and medium energies K and $\bar{K}$-nucleon scattering have not yet been examined. Minami (Ref. 10) and Ball and Frazer (Ref. 11) have made some considerations on the structure of the K-N and $\bar{K}$-N cross-sections at energies near the threshold for production of a real K* resonant state.

We may expect the long range forces to be responsible for large part of the scattering at low and medium energies. Thus we expect the processes involving smaller masses in the intermediate states to be the most important ones. It is perhaps due to the fact that the intermediate states in the K-N interaction are rather massive, that the features of this interaction are so simple (uniform angular distribution, small energy dependence). Fig. 1 shows the Feynman diagrams which have smaller masses in the intermediate states: 1 (a) is the usual Born graph due to the coupling with the Λ and Σ fields; 1 (b) represents the exchange of vector mesons (two and three-pion resonances) between the K-meson and the nucleon. We represent the vector mesons by double dotted lines; ρ is the isovector two-pion broad resonance of Frazer and Fulco, observed at 750 Mev and a half-width $\Gamma/2 \sim 75$ Mev (Ref. 7); ω is the three-pion isoscalar resonance at 785 Mev, with $\Gamma/2 \sim 15$ Mev (Ref. 8). The diagrams (c) and (d) represent the simplest processes in which a K* resonance (Energy 885 Mev, $\Gamma/2 \sim 8$ Mev) (Ref. 12) occurs.

In this paper we show that all the features of the K-nucleon scattering in both I = 0 and I = 1 isotopic spin states can be described in terms of a perturbation calculation of the processes indicated in Fig. 1. We find that only with a definite choice of parities for the Λ and Σ hyperons can the experimental data be reproduced.

The differential cross section in the center of mass system is written

$$\frac{d\sigma}{d\Omega} = |f_1|^2 + |f_2|^2 + (f_1 f_2^* + f_1^* f_2) \cos\theta \qquad (1)$$

where f_1 and f_2 are the non-spin-flip and the spin-flip amplitudes and θ is the scattering angle in the center of mass system. The S-

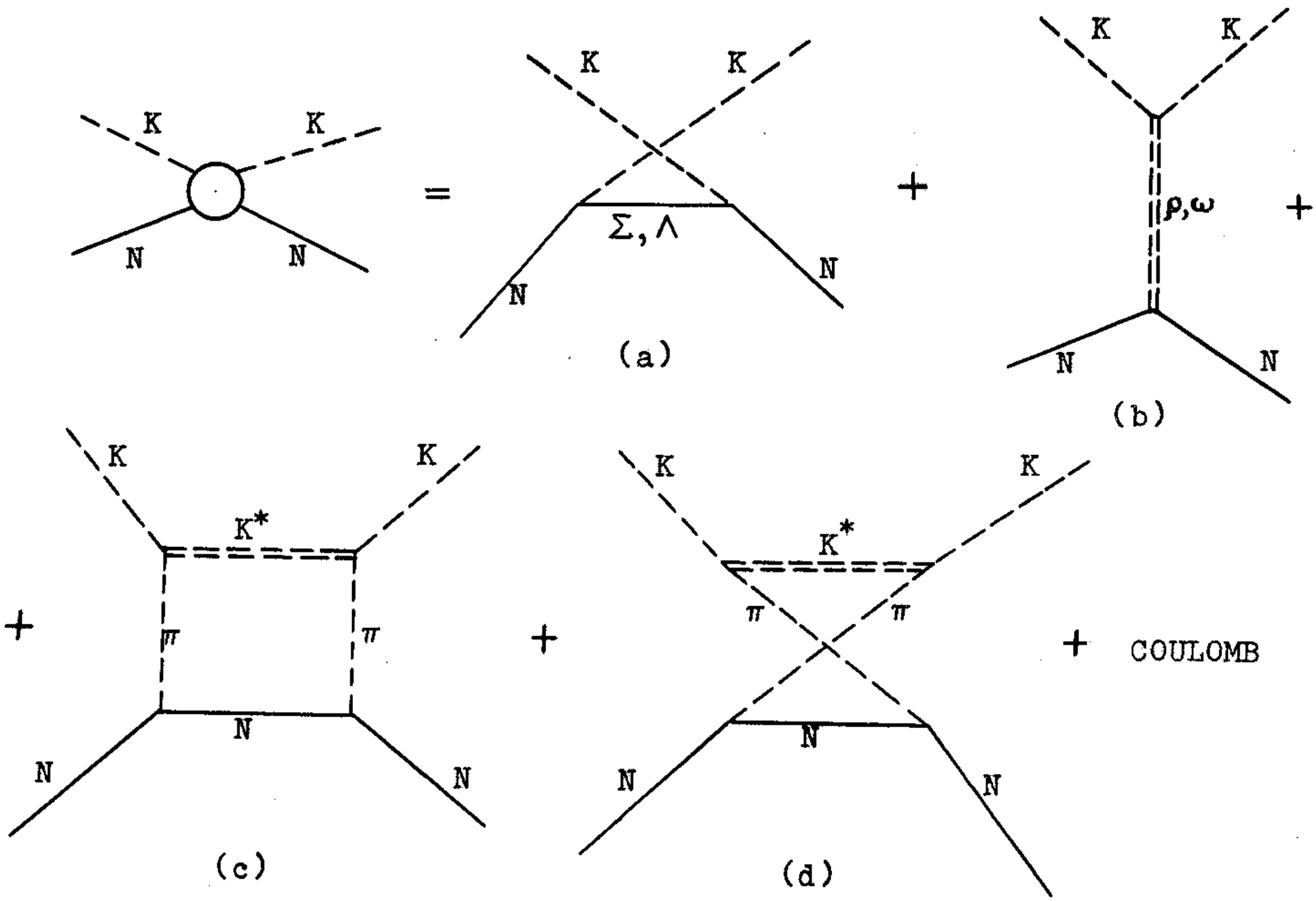

Fig. 1 - Feynman diagrams contributing to K-N scattering in our model. Double dotted lines represent vector mesons. ρ (isovector) and ω (isoscalar) are respectively the two and three pion resonances. K* is the isospinor resonance in the K-π system.

matrix element for meson-nucleon elastic scattering can be written in general

$$S_{if} = \langle f|i\rangle + i(2\pi)^{-2}\delta_4(P_f - P_i)(M/2EU)\left[X\,\bar{\omega}(\vec{p}_3)\omega(\vec{p}_1) + Y\,\bar{\omega}(\vec{p}_3)\gamma_0\omega(\vec{p}_1)\right] \tag{2}$$

where M is the nucleon mass, E and U are the total energies in the center of mass system of the nucleon and the meson respectively and $\vec{p}_1$ and $\vec{p}_3$ are the initial and final proton momenta in the center of mass. X and Y depend on the dynamical structure of the scattering process. f_1 and f_2 are related to X and Y by

$$\begin{aligned} f_1 &= (E+M)\,(Y+X)\,(8\pi W)^{-1} \\ f_2 &= (E-M)\,(Y-X)\,(8\pi W)^{-1} \end{aligned} \tag{3}$$

where $W = E + U$ is the total energy in the center of mass.

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The Fourth Order Diagrams

In the processes (c) and (d) of Fig. 1, in which two pions are exchanged between the K-meson and the nucleon, it is assumed that the K- π interaction occurs mainly through the K* resonance. The observed narrow width of this resonance justifies approximating it by a particle of definite mass (885 Mev) in the Feynman diagrams. The strength of the K* - K - π coupling can be estimated from the width of the resonance (Ref. 13). The isospin of K* is $I = 1/2$.

The angular momentum is not yet well established whether one or zero; however, there is some evidence in favor of spin 1.

If K* is a vector meson we take for the K* - K- π interaction

$$g_{K^*} \bar{K}^*_\mu \underset{\sim}{\tau} \frac{\partial K}{\partial X_\mu} \cdot \underline{\pi} + \text{h.c.} \quad (4)$$

With this interaction, the coupling constant that fits the observed resonance width is

$$g^2_{K^*}/4\pi \approx 1 \quad (5)$$

The values of the scattering amplitudes obtained by numerical computation in a Univac 1105 computer in the case of vector K* are shown in Fig. 2 for several values of the center of mass momentum k. (We use μ = 140 Mev as a convenient unit; μ^{-2} = 20 mb).

Both diagrams (c) and (d), disregrading isospin factors, have the same sign, positive, and about the same order of magnitude at the energies considered. In the I = 1 state the crossed diagram is more important because it enters with an isotopic spin factor 5, while the factor is 1 for the uncrossed graph (c). In the I = 0 the uncrossed graph gives stronger contribution, with an isospin factor 9, against -3 for the crossed diagram. Since 1 + 5 = 9 - 3 we have that for incident meson energies up to 400 Mev in lab the two fourth order graphs give contributions of about the same magnitude and sign for the scattering in both I = 0 and I = 1 states. Since the sign is positive, they contribute like an attractive KN potential.

The results are remarkable in showing an almost isotropic and energy independent behaviour of the I = 1 non-spin-flit amplitude

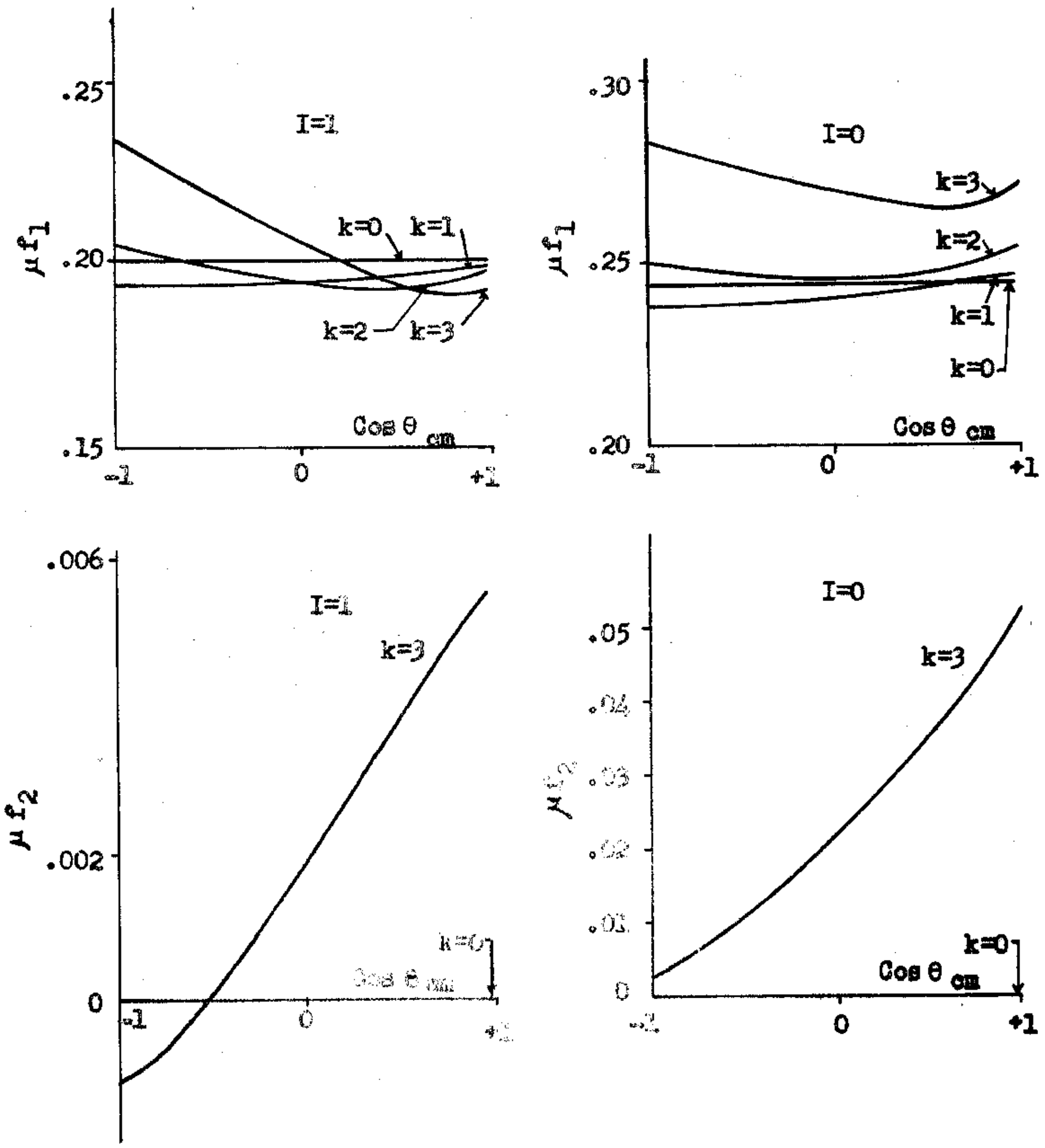

Fig. 2 - Scattering amplitudes f_1 and f_2 for the two fourth order diagrams (c) and (d) of Fig. 1 combined, in the I = 1 and I = 0 isotopic spin states. K* is assumed to be a J = 1, I = 1 particle. k is the momentum in the center of mass system, in units of μ = 140 Mev.

f_1 (f_2 is much smaller than f_1). Besides this, its magnitude is about what is required to give the experimental cross sections. If the contributions coming from all the other processes would cancel themselves, these fourth order terms would give the right K^+-p cross section. However, these terms being attractive would show a destructive interference with the coulomb interaction, while the experimental indication is that the interference is constructive. We thus need strong negative contributions to the I = 1 amplitude coming from other diagrams.

For the case of scalar (J = 0) K* we write the coupling

$$\mu f_{K*} \bar{K}^* \underline{\tau} K \underline{\pi} + h.c. \tag{6}$$

and to satisfy the observed width we must put

$$f^2_{K*}/4\pi \approx 1.6 \tag{7}$$

The scattering amplitudes corresponding to the fourth order diagrams obtained in this case are shown in Fig. 3. We see that in this case we have much stronger angular and energy dependences in the amplitudes. The forward-backward asymmetry indicates a large amount of P-wave contribution to the scattering.

These fourth order diagrams have intermediate states which may consist of real particles if the incident energy is high enough to produce them. At these energies in which the graphs begin to have imaginary parts, the cross sections might display some pelicular structure. We thus expect that for total energies in the center of mass near $W = m_{K*} + M = m_K + M + 391$ Mev something (perhaps

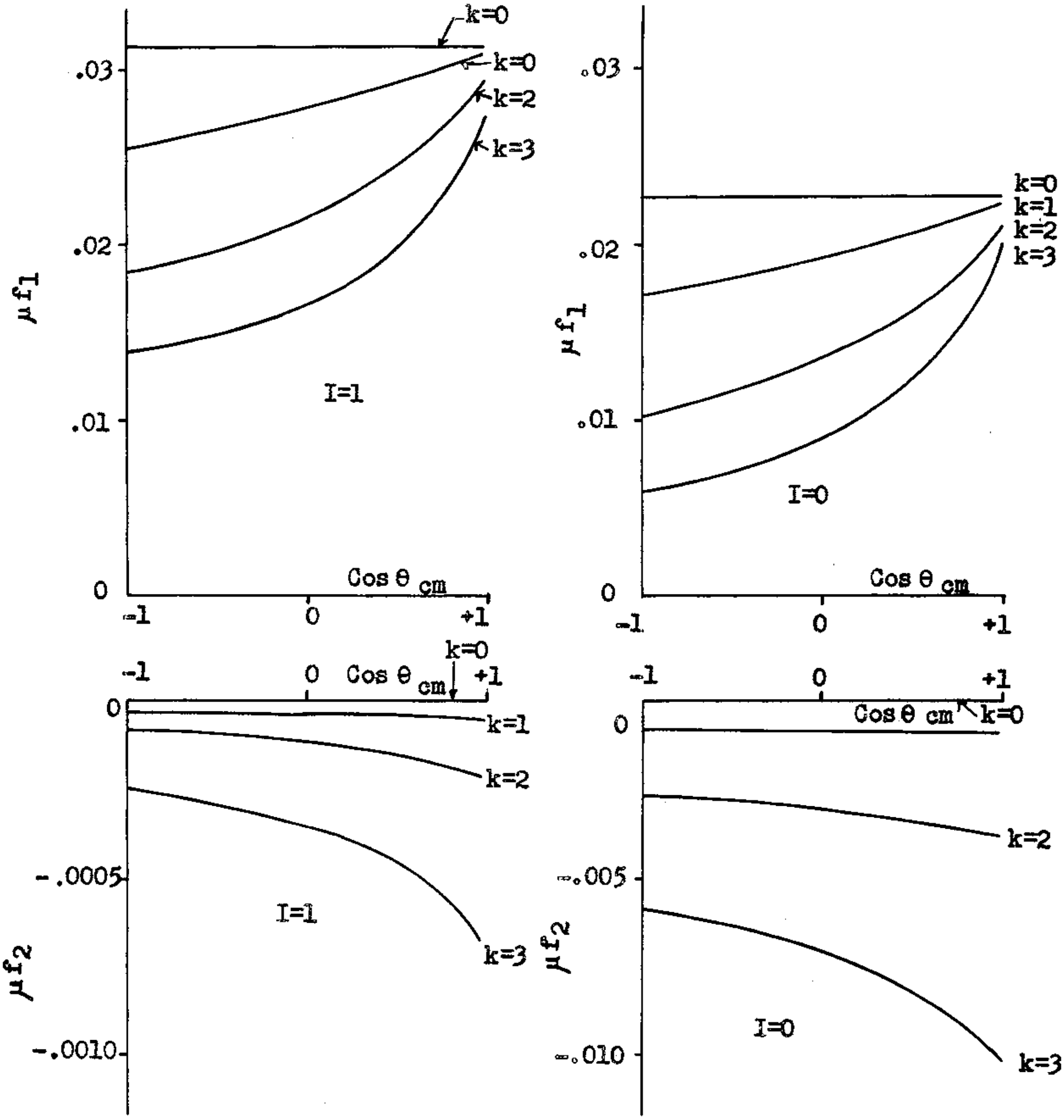

Fig. 3 - Scattering amplitudes f_1 and f_2 in the I = 1 and I = 0 states for the two fourth order diagrams combined together, in the case K* is a scalar (J = 0, I = 1) particle. k is the center of mass momentum, in units of μ = 140 Mev.

a bump) may occur in the K-N cross sections due to the process represented by the diagrams (c). This effect will be stronger in the I = = 0 state (thus in the $K^+n \rightarrow K^0p$ cross section) than in the I = 1 state, due to the ratio 9 : 1 of the isospin factors. This region of energies is not yet explored in detail in K-nucleon scattering, but the bump seen in the $\bar{K}$-p cross section with peak at $W = M + m_K + 380$ Mev (Ref. 14) is just in this region and has probably the same origin, i.e. the production of a real K* in the intermediate state (Note that the isospin factors are the same in both K-N and $\bar{K}$-N scattering for processes involving exchange of two pions).

A rather peculiar behaviour can be predicted for the K^+-p cross section in the region between 1000 and 1120 Mev/c lab momenta. We know the scattering amplitude is negative, but the contribution of the fourth order diagrams (c) is positive. In this region this positive contribution tends to increase rather fast as the energy increases, due to the proximity of a pole in the denominator, so that the whole negative real part of the amplitude tends to decrease in absolute value, the same being true of its contribution to the cross section. Soon the imaginary part due to the real intermediate state starts contributing to increase again the cross section, and this tends to cancel the effect of the reduction of the real part of the amplitude. It may be that the net effect is weak and difficult to observe, but it is possible that it can be seen, as the energy increases, first a decrease in the total cross section, then its increase due to the mass shell contribution.

In the charge exchange process $K^+n \rightarrow K^0p$, on the contrary, the enhancement of the real part of the contribution due to the fourth order graph will cause an increase in the absolute value of the amplitude. This increase will then have its effect on the cross-section reinforced by the contribution from the imaginary mass-shell part. The isotopic spin factor (9-1)/2 = 4 occuring in the fourth order uncrossed graph contribution to $K^+n \longrightarrow K^0p$ would make the effect strong and perhaps easy to be seen in the charge-exchange process.

A real intermediate state in the crossed graph (d) can occur for a center-of-mass total energy $W = M + m_K + 671$ Mev which corresponds to a lab momentum 1687 Mev/c, and again a peculiar behaviour may be observed in the cross section. Here the data on the K-N scattering are still insuficient to show up the effect, but the $\bar{K}$-p data (Ref.14) shows a small bump just in this region.

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Exchange of Resonating Pions

In the fourth order graphs just discussed we considered the exchange of two-interacting pions between the incident K-meson and the nucleon. This exchange was assumed to occur according to a model in which a K* resonance was formed in the intermediate state.

Strong interactions among pions have been recently observed. In particular a rather broad two-pion resonance with I = 1, J = 1 (Energy at the peak 750 Mev, half-width $\Gamma/2$ = 75 Mev) (Ref. 7) and a narrower three-pion resonance with I = 0, J = 1 (Energy 785 Mev, half width

$\Gamma/2$ = 15 Mev) (Ref. 8) have been observed. Experiments have shown that these resonances interact strongly with the nucleons. It is as yet a matter of speculation whether or not they interact with the K-meson field. That is, the charge current of the K-meson may have strong contributions coming from one or both of these pion resonances. In the unitary theories (Ref. 15) for example, there is an interaction with definite couplings at both vertices of diagram (b) of Fig. 1. In this kind of theory, as in the evaluation of the Feynman diagrams, these resonance states are treated as true particles, vector mesons ρ(isovector) and ω(isoscalar) of well defined masses. This may not be so good in the case of the broad I = 1 two-pion resonance, but is probably satisfactory in the case of the isoscalar ω meson. This approximation corresponds to replacing the $\pi - \pi$ cut by a pole in the momentum transfer in a dispersion theory treatment of the two-pion exchange (Ref. 9).

For the coupling of the ρ and ω mesons with the nucleons we write $g_\rho\sqrt{4\pi}\,(\overline{N}\,\underline{\tau}\,\gamma^{\mu}N)\,\underline{\rho}_\mu$ and $g_\omega\sqrt{4\pi}\,(\overline{N}\,\gamma^{\mu}N)\,\omega_\mu$. The coupling with the K meson field takes the form $i\sqrt{4\pi}\,g'_\omega\left[\overline{K}\,\partial_\mu K-(\partial_\mu\overline{K})K\right]\omega_\mu$ with an analogous expression for the ρ-meson. The observed energies of the resonances are so near to each other that we can take them both equal to 785 Mev. Then the isotopic spin factors are such that the contributions of the graphs (b) to the matrix elements are proportional to $a_1 = (g_\omega g'_\omega + g_\rho g'_\rho)$ for the I = 1 state, and to a_o = $= (g_\omega g'_\omega - 3g_\rho g'_\rho)$ for scattering in the I = 0 state. The contributions to the scattering amplitudes f_1 and f_2 due to this kind of graphs are shown in Fig. 4. The strong angular dependence, with important P-wave contribution, is to be noted. If taken by themselves, these graphs would give at 450 Mev lab kinetic energy a forward K-N differential cross section five times larger than that for backward angles. Thus they alone cannot even crudely explain the K^+-p experiments where the angular isotropy is a remarkable feature.

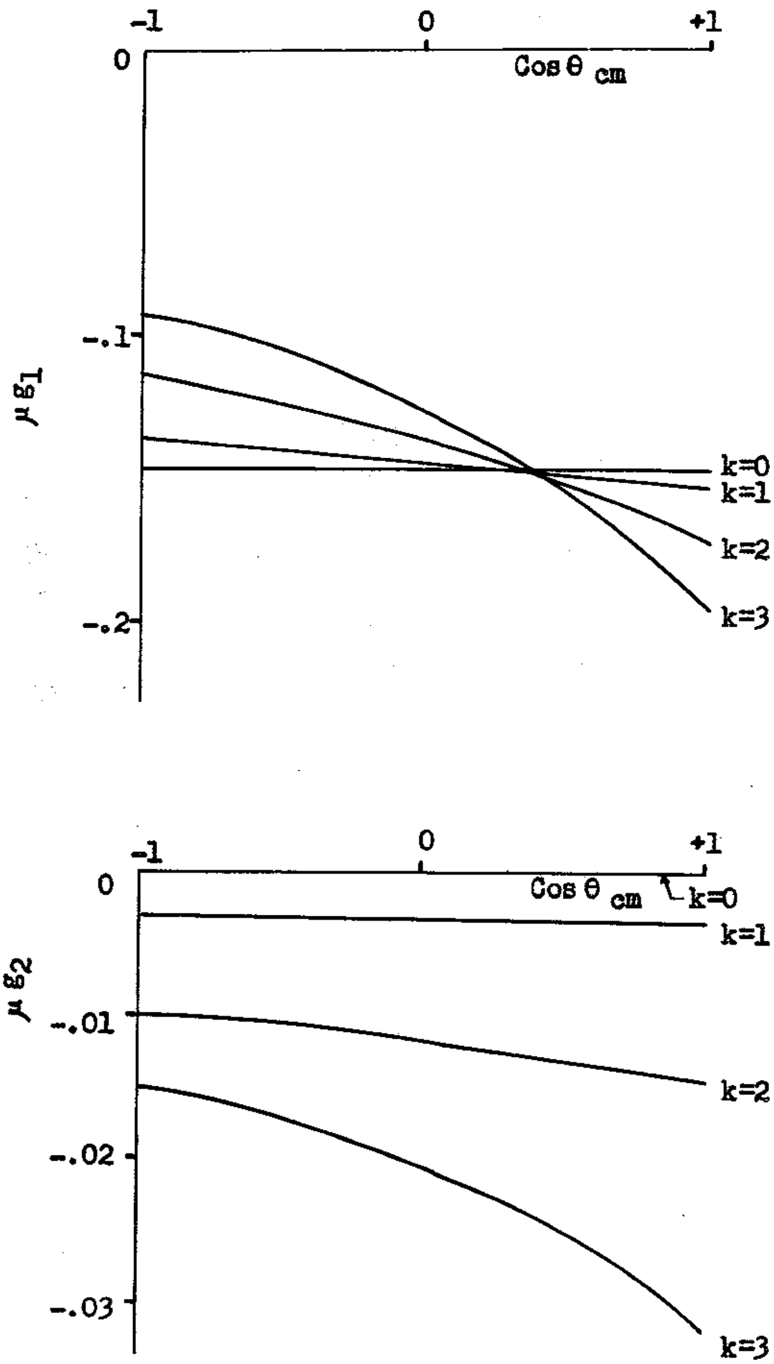

Fig. 4 - Scattering amplitudes for the processes indicated in Fig. 1 (b), involving the exchange of vector mesons of mass 785 Mev. f_1 and f_2 are obtained by multiplying g_1 and g_2 by a_1 or a_o according as I = = 1 or 0.

Hyperon Diagrams

The contributions coming from the diagrams (a), Fig. 1, depend strongly on the parities of the (Λ N K) and (Σ N K) systems. Writing $G_\Lambda^2 = 4\pi g_\Lambda^2$ and $G_\Sigma^2 = 4\pi g_\Sigma^2$ for the squares of the coupling constants, the isotopic spin considerations give that the amplitudes for I = 1 are proportional to g_Λ^2 and g_Σ^2 respectively for Λ and Σ hyperons, while for I = 0 we have $- g_\Lambda^2$ and $3g_\Sigma^2$.

To give an idea of the magnitude and nature of the contributions coming from these processes we plot in Fig. 5 the amplitudes f_1 and f_2 for the Λ diagram, for both cases of odd and even parities, and several energies. For the Σ-hyperon the features are essentially the same.

From the curves we see that the main features in these processes are the following. For positive parity, P(Y K N) = + 1, the amplitude is positive (attractive) and decreases as the energy increases (by a factor of 1/2 from $k = 0$ to $k = 3\mu$). The angular asymmetry increases with the energy so that at $k = 3\mu$ the amplitude for backward angles is 1.5 times that for forward scattering. For negative parity the amplitude is negative (repulsive) and there is very little energy and angular dependence.

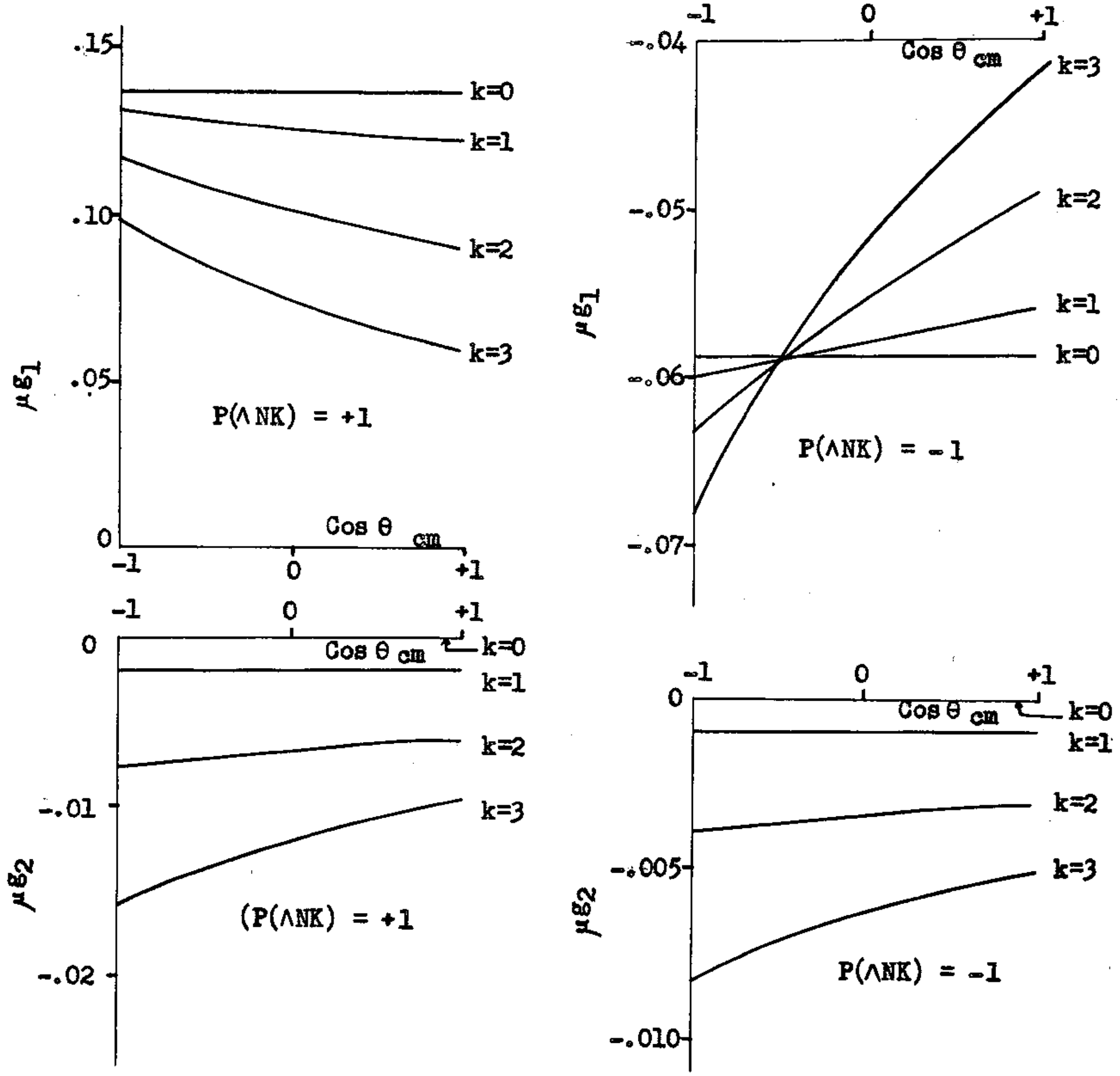

Fig. 5 - Scattering amplitudes for the Λ diagrams indicated in Fig. 1 (a), for either (Λ NK) parities. f_1 and f_2 are obtained by multiplying g_1 and g_2 by the value of g_Λ^2 and by the apropriate isotopic spin factor.

Discussions

We now show that in the framework of our model, we can eliminate the possibilities of all except one combination of parities of the (Λ N K) and (Σ N K) systems.

In this discussion we consider K^* as a vector (J = 1) resonance. The case of scalar K^* can be analysed in a similar manner.

We know from the experiments that the K^+-p (I = 1) interaction is repulsive. Since the fourth order terms give an attractive effect, it would be necessary to find in the second order diagrams a strong repulsive contribution. Considering first the case P(Λ K N) = P(Σ K N) = = + 1, the contributions from the Λ and Σ graphs are both positive (attractive) in the I = 1 state. The exchange of vector mesons would then have to give a repulsive contribution strong enough to compensate the other terms. This would lead to a strong forward peak in the angular distribution, in contradiction with experiments. Thus this case is excluded.

Next consider the case P(Λ K N) = − 1, P(Σ K N) = + 1. We can obtain a fairly good fit to the nearly isotropic angular distribution from k = 0 to k = 3μ, and giving a repulsive potential in the I = 1 state, by choosing $g_\Lambda^2 \approx 10$, $g_\Sigma^2 \approx 1$, $a_1 \approx 1/3$. The Λ coupling has to be so much stronger than the Σ coupling because its term will have to give a large negative contribution to the amplitude (the graphs due to the exchange of pion-resonances, which can also be negative, are not allowed to be made very large because of the large anisotropy they would introduce). Now we have to examine what happens when these values of the coupling constants are used in the I = 0 state. The Λ term will change sign, becoming positive, and the Σ term will be multiplied by three; then all terms will be positive, except that coming from the exchange of the pion resonances, which can be chosen as negative. This negative contribution however cannot be large enough to cancel the large positive sum of the other terms and for reasonable values of a_o one would obtain cross sections for the charge exchange process $K^+n \rightarrow K^op$ more than ten times larger than the experimental values. We conclude therefore that the experimental results for the interactions in the I = 1 and I = 0 states taken together completely exclude this case as well.

For the case $P(\Lambda K N) = + 1$, $P(\Sigma K N) = - 1$, a repulsive nearly isotropic interaction for I = 1 with the required magnitude can be obtained if we set $g_\Lambda^2 \approx 1$, $g_\Sigma^2 \approx 12$, $a_1 \approx 0$. However, in the I = 0 state the Λ contribution changes sign, thus becoming negative, and the negative Σ contribution is multiplied by three. These two terms together are so strong and negative that the cross section for $K^+n \rightarrow K^op$ will result some ten times larger than the experimental value. No reasonable value of a_o characterizing the contribution from the exchange of resonating pions could modify this situation (here again by increasing a_o the angular distribution would become inconsistent with data much before the magnitude of the cross section for $K^+n \rightarrow K^op$ could be reduced to the experimental value).

We should point out that the impossibility of explaining the experimental results with any of the three cases of parities just discussed is not a matter of refinement in fitting the data. The situation cannot be changed by merely adjusting slightly the value of the coupling constant g_{K*} of the $K^* K \pi$ interaction. A strong repulsive graph would have to be added to our model if a solution with these parities had to be found.

The only possibility left is $P(\Lambda K N) = P(\Sigma K N) = -1$. In this case both Λ and Σ graphs are repulsive. Due to the proximity of the values of the masses of Λ and Σ, in the I = 1 state only the combination $(g_\Lambda^2 + g_\Sigma^2)$ of the coupling constants really matters. We can fit the experimental angular distribution for $K^+p \longrightarrow K^+p$ at 455 Mev (Ref. 2) by choosing $g_\Lambda^2 + g_\Sigma^2 = 7.3$ and $a_1 = g_\omega \; g_\omega' + g_\rho \; g_\rho' =$ $= 1/3$. This fitting is shown in Fig. 6. The angular distribution for $k = 2\mu$ using these same parameters is compared to the experimental data (Ref. 1) in Fig. 7. The corresponding curves for $k = 1\mu$ and $k = 0$ are shown in Fig. 8. In Fig. 9 we plot the total $K^+p \rightarrow K^+p$ cross section and put together the experimental data for comparison. It seems that the fitting is quite good.

We now study what happens in the I = 0 state. Here our knowledge comes from the $K^+n \longrightarrow K^0p$ process studied in deuterium and properly analysed (Ref. 3,4). The analysis indicates that the angular distribution in the I = 0 state is consistent with isotropy up to an incident lab momentum 642 Mev/c ($k = 2.64\mu$). The observed values of the cross-section for $K^+d \longrightarrow K^0pp$ correspond to the values of $\sigma(K^+n \longrightarrow K^0p)$ indicated by the points in Fig. 10. Choosing $g_\Lambda^2 =$ $= 5.0$, $g_\Sigma^2 = 2.3$ and $a_0 = 1/3$ we obtain the curves in Fig. 10 and 11 where we see that the angular distribution obtained is consistent with isotropy. The sign of the I = 0 amplitude obtained with this solution is positive (attractive interaction) in agreement with the results of the analysis of the experiments (Ref. 4). Values of g_Λ^2 and g_Σ^2 very different from the above mentioned ones would lead to values of $\sigma(K^+n \longrightarrow K^0p)$ in disagreement with the experimental re-

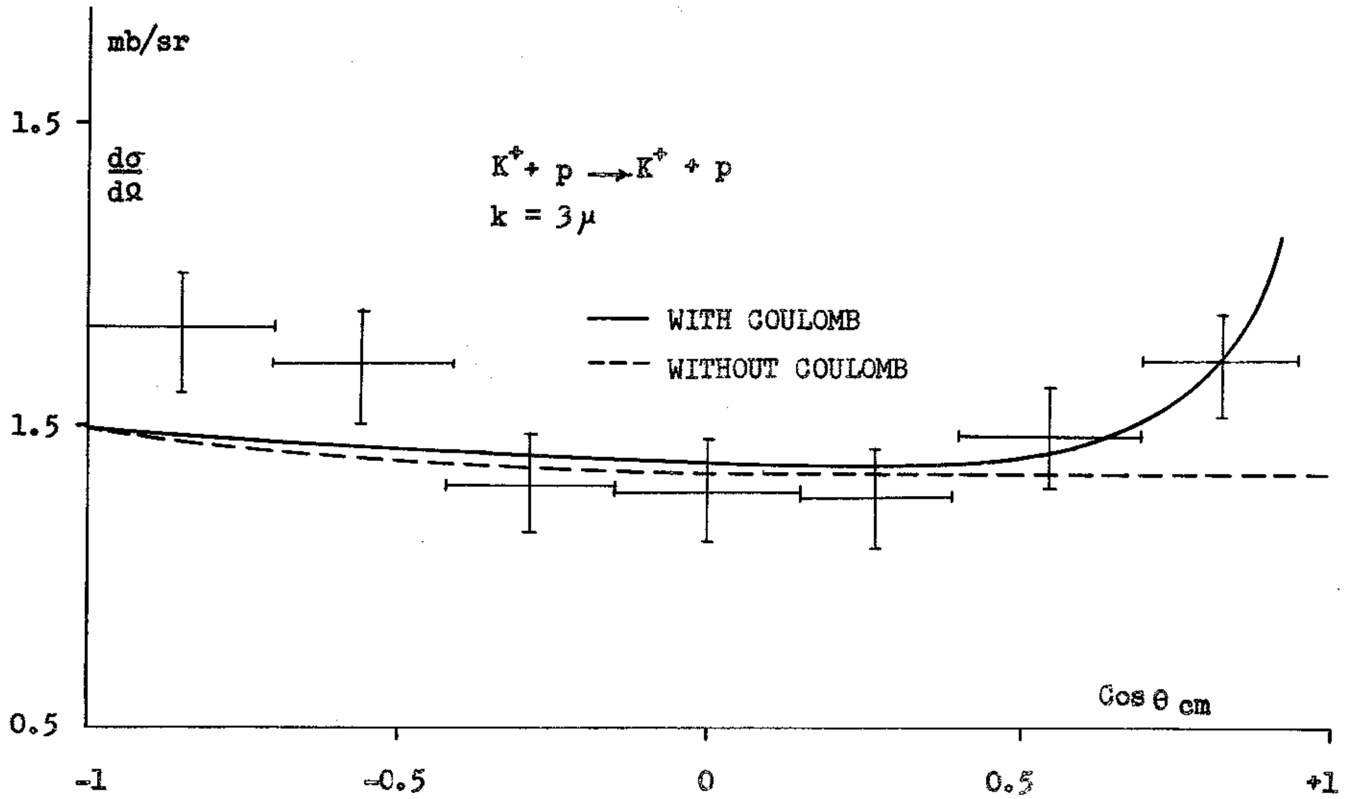

Fig. 6 - Differential cross section for K^+p scattering at 450 Mev lab kinetic energy. The experimental points are taken from reference 2. The curves are the results of the evaluation of the graphs shown in Fig. 1, with $P(\Lambda K N) = P(\Sigma K N) = -1$, $g_\Lambda^2 + g_\Sigma^2 = 7.3$ and $a_1 = g_\rho g'_\rho + g_\omega g'_\omega = 1/3$.

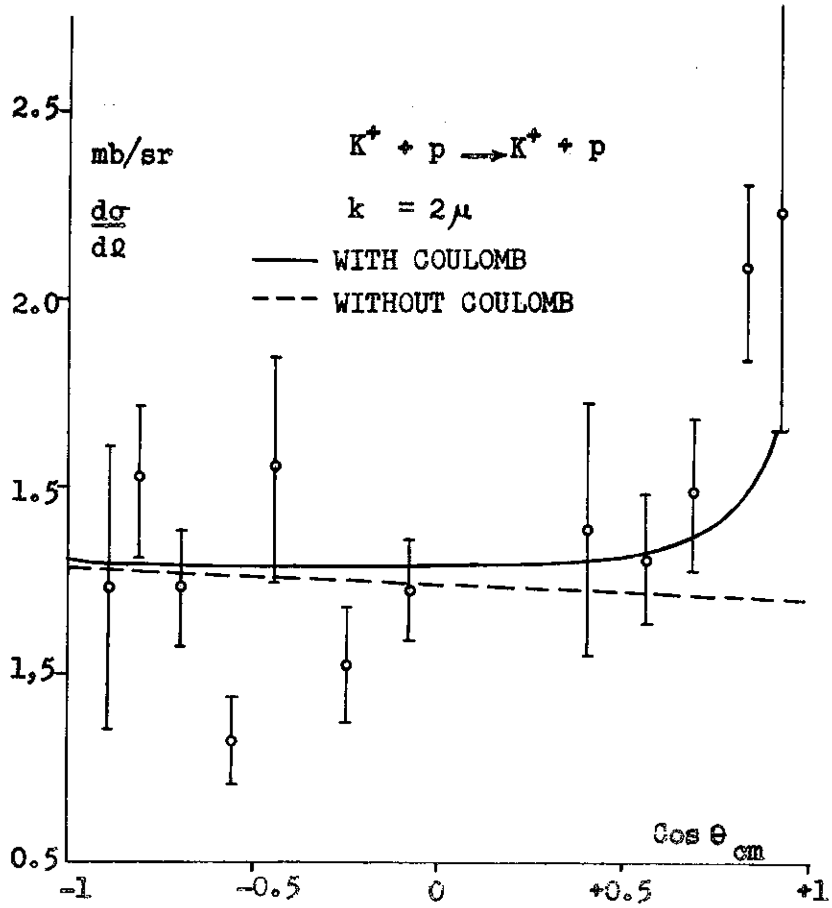

Fig. 7 - Differential cross section for $K^{+}p$ scattering at 225 Mev lab kinetic energy. The experimental points are from reference 1. The curves are the results from the evaluation of the graphs shown in Fig. 1, with $P(\Lambda KN) = P(\Sigma KN) = -1$, $g_{\Lambda}^{2} + g_{\Sigma}^{2} = 7.3$ and $a_1 = 1/3$.

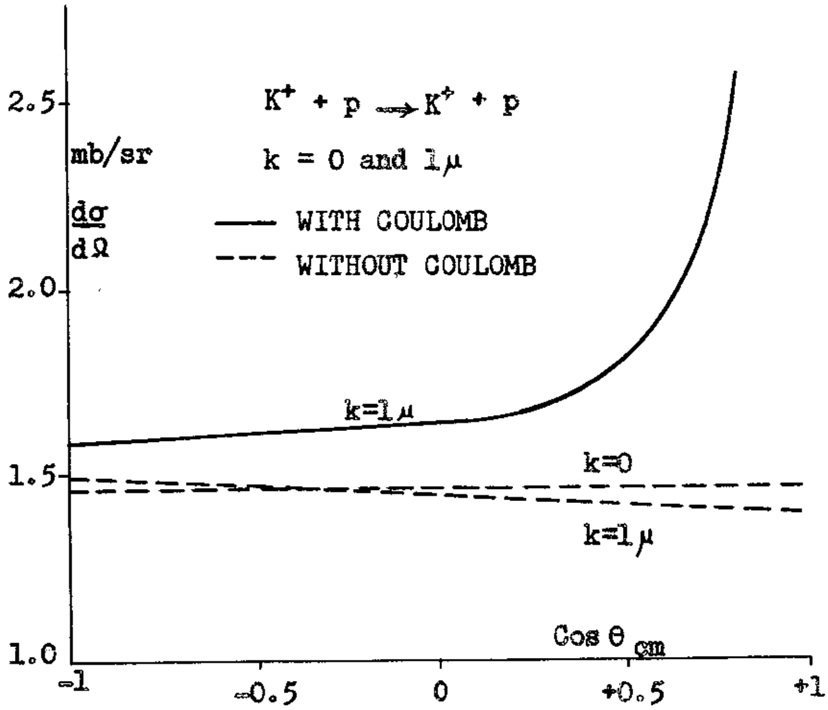

Fig. 8 - Differential cross section for K^+p scattering for zero and about 45 Mev lab kinetic energies. The curves are obtained by evaluating the diagrams of Fig. 1, with $P(\Lambda KN) = P(\Sigma KN) = -1$, $g_\Lambda^2 + g_\Sigma^2 = 7.3$, $a_1 = 1/3$.

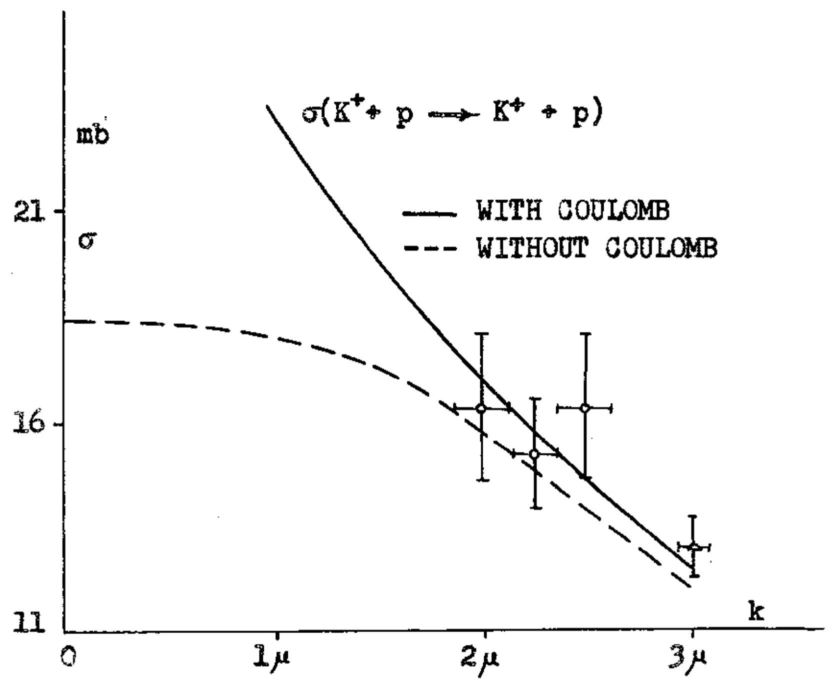

Fig. 9 - Total cross section for K^+p scattering against the center of mass momentum k. (μ = 140 Mev/c). The experimental points are from references 1 and 2. The curves are the results of the calculation of the set of graphs indicated in Fig. 1, with $P(\Lambda KN) = P(\Sigma KN) = -1$, $g_\Lambda^2 + g_\Sigma^2 = 7.3$, $a_1 = 1/3$.

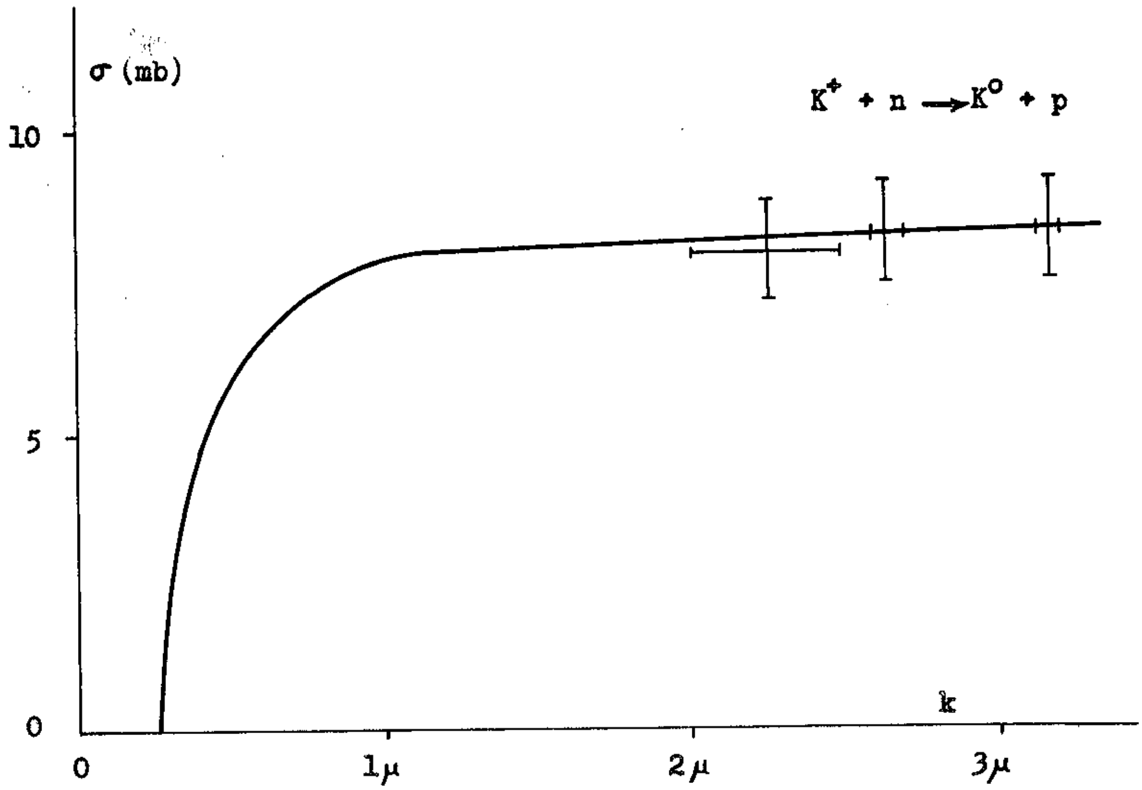

Fig. 10 - Cross section for the charge-exchange process $K^+n \to K^0p$ against the center of mass momentum k. The experimental points are from references 3 and 4. The curve is the result of calculation of the graphs shown in Fig. 1, with $P(\Lambda KN) = P(\Sigma KN) = -1$, $g_\Lambda^2 = 5$, $g_\Sigma^2 = 2.3$, $a_1 = 1/3$, $a_0 = g_\omega g'_\omega - 3g_\rho g'_\rho = 1/3$.

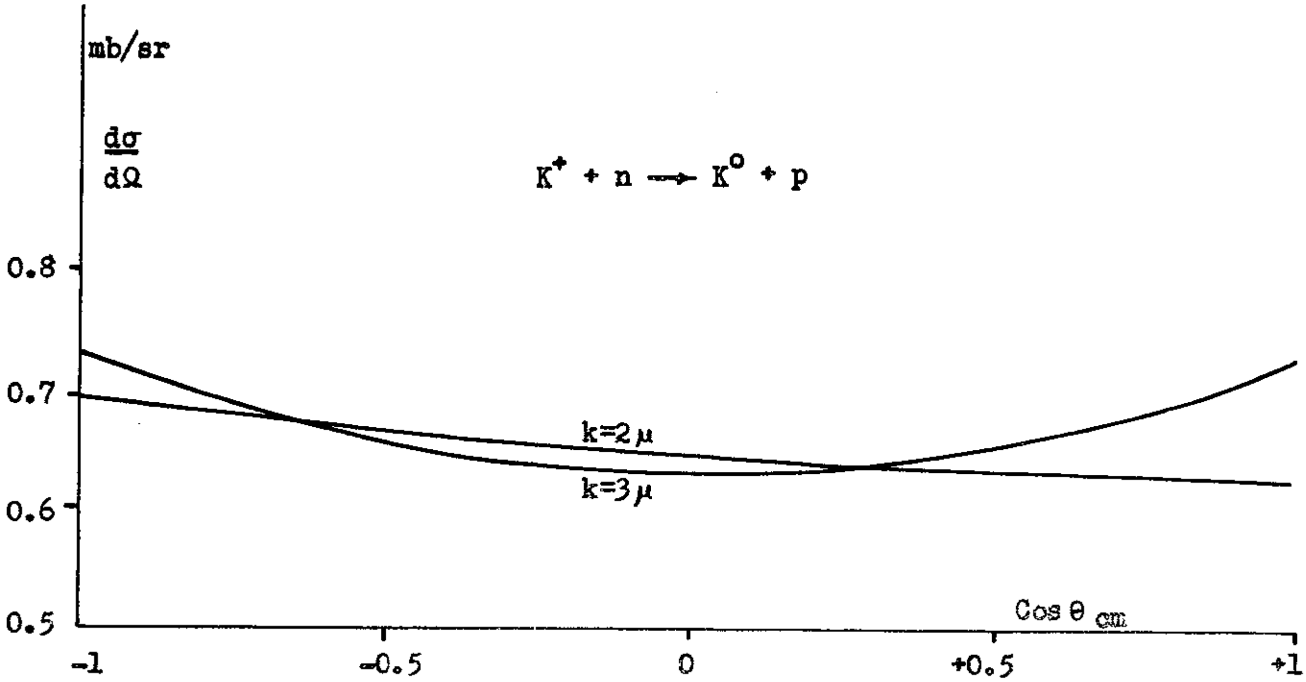

Fig. 11 - Differential cross section for $K^+n \rightarrow K^o p$ for lab kinetic energies near 200 and 400 Mev (center of mass momenta $k = 2\mu$ and 3μ respectively) resulting from evaluation of the diagrams of Fig. 1, with $P(\Lambda KN) = P(\Sigma KN) = -1$, $g_\Lambda^2 = 5$, $g_\Sigma^2 = 2.3$, $a_1 = a_o = 1/3$. The rather flat angular distributions are in agreement with the analysis of the K^+-deuterium experiments.

sults. Any value of a_o very different from 1/3 would modify strongly the angular distributions of Fig. 10, 11, introducing a strong angular dependence contradicting the experiments. Equal values of a_1 and a_o, which were both chosen as 1/3 in order to satisfy the condition of nearly isotropic amplitudes mean that, in the framework of our model the isovector two-pion resonance (the ρ meson) has a negligible contribution to the K - N scattering (g'_ρ would be small). Thus only the isoscalar resonance would contribute to the graph in b, with $g_\omega g'_\omega = G_\omega G'_\omega /4\pi = 1/3$. From the point of view of the use of a straightforward perturbation calculation this is a pleasant result, because ω is a narrow resonance, with quite well defined mass, while ρ is a rather broad one.

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<u>Conclusions</u>

The set of experimentally observed features of the K-nucleon interaction in both I = 1 and I = 0 isotopic spin states can be understood on the basis of a simple perturbation model involving only a few low order diagrams. The only choice of parities of the Λ and Σ hyperons that are compatible with experimental data is P(Λ K N) = P(ΣKN) = -1. Other choices give strong disagreement with the data. The contributions from the fourth order diagrams due to the existence of a vector K* resonance are large (of the order of magnitude necessary to give by themselves cross sections of the order of the experimental values) and attractive in both isospin states. The exchange of the two-pion I = 1, J = 1 resonance between the K meson and the nucleon seems to have very small effect, but the exchange of the three-pion I = 0, J = 1 resonance has an important role in preserving the isotropy in the differential cross section.

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References:

1. T. F. Kycia, L. T. Kerth, R. G. Baender - Phys. Rev. 118, 553 (1960).

2. T. F. Stubbs et al. - Phys. Rev. Lett. 7, 188 (1961).

3. W. Slater et al. - Phys. Rev. Lett. 7, 378 (1961).

4. E. M. Ferreira - Annals of Physics, 17, 159 (1962).

5. I. R. Gatland - Nuclear Physics, 15, 480 (1960).

6. M. Azuma and T. Ebata - Progr. Theor. Phys., 24, 1329 (1960).

7. A. R. Erwin et al., Phys. Rev. Lett., 6, 628 (1961); D. Stonehill et al., Phys. Rev. Lett., 6, 624 (1961); E. Pickup et al. - Phys. Rev. Lett., 7, 192 (1961).

8. L. Alvarez et al., Phys. Rev. Lett., 7, 178 (1961); M. H. Xuong and G. R. Lynch, Phys. Rev. Lett., 7, 327 (1961).

9. B. W. Lee - Phys. Rev., 121, 1550 (1961).

10. S. Minami - Progr. Theor. Phys., 25, 863 (1961).

11. J. S. Ball and W. R. Frazer - Phys. Rev. Lett., 7, 204 (1961).

12. M. Alston et al. - Phys. Rev. Lett., 6, 300 (1961).

13. S. W. MacDowell, A. L. L. Videira, N. Zagury - Nuclear Physics, to be published.

14. L. T. Kerth, Rev. Mod. Phys., 33, 389 (1961).

15. M. Gell-Mann, Phys. Rev., to be published; M. Ikeda, S. Ogawa and Y. Ohnuki - Progr. Theor. Phys., 22, 715 (1959).

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