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Amplitude Analysis of Hypercharge Exchange Reactions.*

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ABSTRACT

We present a smooth parameterization of the amplitudes for meson-baryon hypercharge exchange reactions which describes well all the presently available data for laboratory momenta above 3 GeV/c. The K_V^* (resp. K_T^*) amplitudes we find are very similar to the ρ , ω (resp. f , A_2) amplitudes obtained already by other authors. The SU(3) assumption seems to be well supported by the experimental data.

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Introduction.

While a strictly model-independent determination of inelastic-two-body amplitudes is still possible only for ρ -exchange in $\pi^- p \rightarrow \pi^0 n$ at 6 GeV, ⁽¹⁻⁵⁾ numerous recent phenomenological analyses have also extracted the ρ -exchange amplitudes at other energies and have also extracted the A_2 -exchange amplitudes by supplementing the incomplete set of observables by a few, rather plausible, theoretical assumptions ⁽⁶⁻¹¹⁾. Numerous other analyses have extracted these amplitudes in the context of specific models ⁽¹²⁻¹⁴⁾. These various analyses seem to establish a definite systematics for ρ and A_2 exchange amplitudes, both for their shape in t and their energy dependence.

In this paper we present a quantitative analysis of all the available data for meson-baryon hypercharge exchange reactions above 3 GeV/c to determine whether the same systematics as found for ρ, A_2 exchange applies also for K_V^* and K_T^* .

We begin by recalling the main features of the ρ (vector) and A_2 (tensor) exchange amplitudes. The imaginary part of the ρ nonflip amplitude is peripheral ⁽¹⁵⁾ (cross-over zero at $t \approx -0.2 (\text{GeV}/c)^2$) and the real part vanishes after the imaginary part (the polarization of $\pi^- p \rightarrow \pi^0 n$ is positive up to $t \approx -0.6 (\text{GeV}/c)^2$). The real part of the A_2 non flip-amplitude has a single zero at $t \approx -0.4 (\text{GeV}/c)^2$ whereas the imaginary part has a double zero in the same vicinity which might correspond to a non compensation mechanism ⁽¹⁶⁾ at $\alpha_{A_2}(t) = 0$.

As far as the flip amplitudes are concerned, it seems that to first approximation the ρ and A_2 are Regge-like and exchange degenerate in $K^- p \rightarrow \bar{K}_0 n$. The observed difference with the differential cross section of the line reversed reaction can be explained by a small displacement of the A_2 trajectory below that of the ρ ⁽¹⁰⁾. The zero of the ρ flip amplitude at $\alpha_\rho(t) = 0$ can explain the dip observed in $\pi^- p \rightarrow \pi^0 n$. SU(3) is well satisfied by ρ and A_2 exchange.

The effective trajectories of the ρ and A_2 determined using data from 6 to 100 GeV/c⁽⁷⁾ have slopes much closer to the pole slope (≈ 1 (GeV/c)⁻²) than to typical cut behavior where a much smaller slope would be expected. The effective trajectory of the A_2 is 0.1 lower than the ρ , in agreement with the line reversal results already mentioned.

There is evidence that other vector exchange amplitudes such as ω , K_V^* (18-23), or other tensor exchanges such as f , K_T^* (19,20,22,24), exhibit similar t -dependences. However in these cases the evidence is in general not as compelling. The exchange of f , for example, is very difficult to isolate from Pomeron exchange⁽²⁵⁾. To isolate the K_V^* and K_T^* non-flip amplitudes, Irving, Martin, and Barger⁽¹⁹⁾ (IMB) made the rather strong assumption that the flip amplitudes are exactly exchange degenerate, whereas this approximation is accurate at best to 10-20% for ρ , A_2 near 6 GeV/c. Girardi and Navelet⁽²²⁾ have shown that the assumption to ρ (resp. A_2) is compatible with the hypercharge exchange data at 6 GeV/c for $|t|$ less than 1 (GeV/c)².

The available evidence concerning the energy dependence of vector and tensor exchange is very limited. The f cannot be reliably separated from the Pomeron⁽²⁵⁾. The flip ω amplitude is generally small while the non-flip amplitude, being peripheral, is large over too small a t -range to determine much more than an effective intercept. The effective trajectories for K_V^* and K_T^* exchange, as determined by IMB show no clear systematics and are not conclusive in determining whether these trajectories have more pole or cut-like energy dependences.

In this paper we attempt to determine whether the above systematics, firmly established for ρ and A_2 , is satisfied in detail by K_V^* and K_T^* exchange. Our analysis is based on a Regge-Pole plus effective-cut parameterization of the exchange amplitudes. Our Regge-Pole amplitudes have wrong-signature-nonsense zeros (WSNZ). Cuts are assumed negligible in flip amplitudes with the WSNZ

able to explain the observed systematics. Cuts are needed in the non flip amplitudes to produce the cross over zero for the vector amplitude, the t structure previously described for the tensor, to alter the phase as needed to explain quantitatively the polarization, and to investigate the deviations from pole-like energy dependence. We also study the SU(3) and line reversal properties of the reaction amplitudes.

In part II, we present our parameterization. The third part is devoted to the comparison with the experimental data. We summarize our results in the conclusion.

II. Description of the Parameterization.

a). Conventions.

Our normalization conventions are such that the observables are given in terms of the s -channel helicity amplitudes H_{++} , H_{+-} as follows:

$$\frac{d\sigma}{dt} = |H_{++}|^2 + |H_{+-}|^2$$

$$P \frac{d\sigma}{dt} = -2\text{Im} (H_{++} H_{+-}^*)$$

$$S \frac{d\sigma}{dt} = |H_{++}|^2 - |H_{+-}|^2$$

$$T \frac{d\sigma}{dt} = -2\text{Re} (H_{++} H_{+-}^*)$$

$$R = -\cos\theta_R S + \sin\theta_R T$$

$$A = \sin\theta_R S + \cos\theta_R T$$

where

$$\cos\theta_R = \left(\frac{-t}{4M^2 - t} \right)^{1/2} \left(\frac{E_{\text{lab}} + M}{p_{\text{lab}}} \right)$$

Our relative sign conventions are as given by Martin et al⁽²⁶⁾, namely the non-flip amplitude for the non-exotic reaction $\pi^- p \rightarrow K^0 \Lambda$ is given by

$$H_{++} = -K_V^* - K_T^*$$

while for the exotic case $K^- n \rightarrow \pi^0 \Lambda$

$$H_{++} = K_V^* - K_T^* .$$

The overall sign convention is such that, in the limit of exact exchange degeneracy, $K_V^* - K_T^*$ would be real and negative while $-K_V^* - K_T^*$ would have a positive imaginary part.

b). The Data.

We have included in this work all the data available up to now in the 3-17 GeV/c range⁽²⁷⁻³⁰⁾.

$$\pi^- p \rightarrow K^0 \Sigma^0 \quad (27)$$

$$\pi^- p \rightarrow K^0 \Lambda \quad (27)$$

$$\pi^+ p \rightarrow K^+ \Sigma^+ \quad (28)$$

$$K^- n \rightarrow \pi^- \Lambda \quad (29)$$

$$K^- p \rightarrow \pi^0 \Lambda \quad (30)$$

$$K^- p \rightarrow \pi^- \Sigma^+ \quad (30)$$

We recall briefly the trends of the data (see figures 1 - 3).

b₁) Differential Cross Section.

i) The exotic one is larger for small t than its s-u crossed reaction : $\frac{d\sigma^E}{dt} > \frac{d\sigma^{NE}}{dt}$. This inequality has been a challenge for the classical absorption model which predicts that the inequality goes the wrong way because the "real" amplitude is more absorbed than the non-exotic one.⁽³¹⁾

ii) There is no turnover near $t = 0$ which suggests that the flip amplitude is not the dominant one as in $\pi^-p \rightarrow \pi^0n$ or $\pi^-p \rightarrow \eta n$ reactions. Each cross section has an exponential forward peak followed by a break near $t \approx -0.4, -0.5 \text{ (GeV/c)}^2$ which is more pronounced for the non-exotic case.

iii) There is no evidence for an exchange of $I_t = 3/2$ in the Σ case. Indeed assuming pure $I_t = 1/2$ leads to the relation $\frac{1}{2} \frac{d\sigma}{dt} (\pi^+p \rightarrow K^+\Sigma^+) = \frac{d\sigma}{dt} (\pi^+p \rightarrow K^0\Sigma^0)$ which is in good agreement with the data at 4 GeV/c Ward⁽²⁷⁾. However at 3 GeV/c there is a discrepancy between Kalbaci⁽²⁸⁾ and Pruss⁽²⁸⁾ as already quoted by Ward et al⁽³²⁾. Apparently the sharp change of slope near $t \approx -0.1 \text{ (GeV/c)}^2$ in the 3 GeV/c $\pi^+p \rightarrow K^+\Sigma^+$ cross section is not at all seen in the $\pi^-p \rightarrow K^0\Sigma^0$ data of Ward.

Therefore since our analysis assumes no $I_t = 3/2$ component, we have not considered the Pruss et al. data at 3 GeV/c and 3.25 GeV/c.

b₂) Polarization.

The experimental accuracy on the polarization is unfortunately poor. Nevertheless the trend of these data is clear. The exotic polarization and the non-exotic one have the same sign near $t = 0$, then the non-exotic changes sign near $t \approx -0.1, -0.2 \text{ (GeV/c)}^2$ and is then roughly mirror symmetric of the exotic one. This has to be compared to the situation in the KN charge exchange reaction at 6 GeV/c where both the ρ and A_2 contributes.

The non-exotic polarization $K^- p \rightarrow \bar{K}_0 n$ has been measured⁽³³⁾ at 7.95 GeV/c and exhibit the structure near $t = -0.1, -0.2$. The exotic one has not yet been measured but an SU(3) Barger-Cline sum rule gives a prediction since we know the polarization in $\pi^- p \rightarrow \pi^0 n$, $\pi^- p \rightarrow \eta n$, and $K^- p \rightarrow \bar{K}_0 n$. In Ref. 6 we showed this prediction. The polarization is similar to the hypercharge exchange exotic reaction which seems to corroborate our feeling about the universality of the vector and tensor exchange.

c) Parameterization.

We parameterize our amplitudes in terms of Regge poles with WSNZ and effective Regge cuts. First, we present the pole amplitudes:

$$H_{++}^{\Lambda, \Sigma} = K \gamma_{++}^{\Lambda, \Sigma} (\tau + e^{-i\pi\alpha(t)}) s^{\alpha(t)} e^{a_{++}t}$$

$$H_{+-}^{\Lambda, \Sigma} = K \sqrt{-t'} \gamma_{+-}^{\Lambda, \Sigma} (\tau + e^{-i\pi\alpha(t)}) s^{\alpha(t)} e^{a_{+-}t}$$

where

$$K^2 = \frac{.38935 M^2}{16\pi p_1^2 s} \text{ mb}/(\text{GeV}/c)^2$$

and

$$\sqrt{-t'} = \sqrt{-(t - t_{\min})}$$

In the above, τ is the signature, $\alpha(t)$ the trajectory function, γ_{++}^{Λ} , γ_{+-}^{Λ} , γ_{++}^{Σ} , γ_{+-}^{Σ} are the residues for the reactions $\pi^- p \rightarrow K^0 \Lambda$ and $\pi^- p \rightarrow K^0 \Sigma^0$ respectively (the overall sign and relative signs for other reactions have been given above), and a_{++} , a_{+-} give the exponential t -dependence. In principle, $\alpha(t)$, the a 's, and the γ 's could be unrelated in the Λ and Σ channels. As noted above $\alpha_{A_2^*}(0)$ is definitely lower than $\alpha_{\rho}(0)$, thus we also allow splitting of the K_V^* and K_T^* trajectories. For want of enough data, we take the slopes of the pole trajectories to be the same. If SU(3) were valid, the γ 's in the Λ and Σ channels would be related and the a 's would be the same (although they could differ for K_V^* and K_T^*). The analysis of IMB suggest significant differences in the t -dependence of the amplitudes in the Λ and Σ channels thus suggesting large breaking of simple SU(3), away from $t = 0$ at least. We investigate the validity of the SU(3) relations by allowing all four γ 's (γ_{++}^{Λ} , γ_{++}^{Σ} , γ_{+-}^{Λ} , and γ_{+-}^{Σ}) to be independent in the fitting and afterwards we check their values with the SU(3) relations for accepted F/D ratios^(26,34). We assume that the shapes of K_V^* and K_T^* are the same in the Λ and Σ channels, i.e. a_{++} and a_{+-} do not depend on the channel. Since exchange degeneracy breaking is small in H_+ for ρ , A_2 we take $a_{+-}(K_V^*) = a_{+-}(K_T^*)$ and incorporate all exchange degeneracy breaking effects in the residue and trajectory splitting.

Following the results for ρ , A_2 exchange we assume no cuts in the flip amplitudes. However the known systematics of ρ , A_2 non-flip amplitudes cannot be described by poles alone, thus we are forced to introduce cuts. The known features of the non-flip amplitudes which require cuts are 1) peripherality for the imaginary part of the vector amplitude and eventually a zero (or minimum) for the real part after the zero of the

imaginary part; ii) single zero for the real part of the tensor near $t \approx -0.4, -0.5 \text{ (GeV/c)}^2$ and a double zero or minimum in the same vicinity.

One could try to avoid introducing cuts by multiplying the non-flip K_V^* by $(1. + t/.2)$ and the non-flip K_T^* by $(1. + t/.45)$, which would roughly give the behavior i) and ii) described above. However in any model with only one effective pole for each signature, it is always true that $\bar{P} \, d\bar{\sigma}/dt = -P \, d\sigma/dt$ for the pairs of line-reversed reactions⁽³⁵⁾. Thus to describe the fact that the polarizations have the same sign, we need additional terms which we call effective cuts.

Our effective-cut amplitudes read

$$H_{++}^{\Lambda, \Sigma} = K_{++}^{\Lambda, \Sigma} \gamma^c \frac{1}{-1} \left(e^{\frac{-i\pi}{2} s} \right)^{\alpha_c(t)} a_c^t$$

where (1) is for K_V^* , (-1) for K_T^* , and γ^c is the effective-cut strength relative to the pole. The effective-cut trajectory is $\alpha_c(t) = \alpha_c(0) + \alpha'_c t$. Following our discussion for the pole, we take γ^c , a_c , $\alpha_c(t)$ different for K_V^* and K_T^* but the same in Λ and Σ channels. We have introduced an effective-cut rather than calculated it from some conventional model⁽³⁶⁾ because conventional absorption models give i) line reversal breaking going the wrong way near $t = 0$ ⁽³¹⁾; ii) the effective trajectory of the cut much flatter than observed in $\pi^- p \rightarrow \pi^0 n$ and $\pi^- p \rightarrow \eta n$ ⁽¹⁷⁾. Note that conventional absorption models give cuts proportional to $s^{\alpha_c} / (A + B \ln s)$ where $\alpha_c(0) = \alpha(0)$, $\alpha'_c \ll \alpha'$ and A and B determined in terms of the Regge-pole and Pomeron pole parameters. Our effective cut can reproduce this behavior over a finite energy range. We can thus determine whether or not the data favor conventional absorptive cuts or the more pole-like cuts found in ρ and A_2 exchange reactions. From the example of ρ , A_2 , we expect our $\alpha_c(0) \leq \alpha(0)$ and $\alpha'_c \leq \alpha'$. For simplicity we let $\alpha_c(0)$ be different for K_V^* and K_T^* but take the cut slopes the same.

To summarize, for the Λ reactions we have 17 parameters to describe both the poles and cuts. Then to describe the Σ reactions, we have 4 additional parameters, the pole residues. If SU(3) were valid the ratio $\gamma^\Sigma/\gamma^\Lambda$ would be given by the SU(3) Clebsch Gordon coefficient

$$\gamma^\Sigma/\gamma^\Lambda = \sqrt{3} \left(\frac{2F - 1}{2F + 1} \right) \quad \text{with } F + D = 1$$

and with F consistent with other determinations^(26 - 34). We expect $F^T \sim F^V$ if exchange degeneracy is approximately valid.

III. Results.

Using the pole-plus-effective-cut parameterization of the previous section we have determined the 21 free parameters by fitting simultaneously all the available differential cross section and polarization data above 3 GeV/c and for $|t|$ less than 1.5 (GeV/c)². There are at present no measurements of the R and A spin correlation parameters. Our data set consisted of 500 experimental points for the Σ case and 316 for the Λ case. The values of the parameters are listed in the table below.

	Vector	Tensor
$\alpha(t)$	$0.375 + 0.678t$	$0.322 + 0.678t$
γ_{++}^Σ	10.34	11.15
γ_{++}^Λ	12.46	12.83
γ_{+-}^Σ	-9.862	-7.114
γ_{+-}^Λ	13.53	11.63
a_{++}	2.414	1.331
a_{+-}	1.895	1.895
$\alpha^c(t)$	$0.099 + 0.532t$	$0.127 + 0.532t$
γ^c	1.01	2.88
a^c	1.134	0.091

The γ 's are in units of $(\text{mb}/(\text{GeV}/c)^2)^{1/2}$, the a 's in $(\text{GeV}/c)^{-2}$.

Note that the trajectory parameters are quite compatible with the trajectory $\alpha = 0.35 + 0.82t$ which passes through the particle masses. The effective cut trajectories are also in line with expectations, i.e. the cut intercepts and slope are lower than those of the corresponding poles. However as in $\pi^- p \rightarrow \pi^0 n$ the effective cut has a slope much closer to that of the pole⁽¹⁷⁾ than that of the absorptive cut generated by a conventional absorption model⁽³⁶⁾.

The χ^2 per degree of freedom is 1.81. In our fits we varied the experimental normalizations within the quoted errors.

Fig. 1 shows that our parameterization reproduces well all the differential cross section data with no clear systematic discrepancies in either the t or s dependence.

Fig. 2 shows that our parameterization also describes perfectly adequately all the polarization data. There is a possible discrepancy at small $-t$ in $\pi^- p \rightarrow K^0 \Lambda$ where our polarization is smaller in magnitude than the trend of the rather inconsistent experimental data. We return to this point later when we compare our results with previous analyses.

Fig. 3 shows how well we reproduce the line reversal breaking. Note that we find an adequate description of the line reversal behavior of Λ and Σ reactions with K_V^* and K_T^* amplitudes that have the same shape in the two reactions. IMB found very different shapes in the different reactions. Referring to Figs. 1 and 3 we conclude that the results of Ref. 19 were based on very few data points near $t \approx -1.5$ and that, when all the data are considered, there is no compelling reason to have substantially different t -dependence in the Λ and Σ reactions.

In Fig. 3 we also present our predictions for 14 GeV/c to show the rather smooth behavior we predict for the line reversal breaking as a function of energy.

Fig. 4 shows our amplitudes at 4 GeV/c. The structure of the non-flip is slightly s dependent since the cut contribution has a different energy dependence than the pole one (α pole ≈ 0.38 , α cut ≈ 0.1).

The main result, as far as the vector non-flip is concerned, is the peripherality of its imaginary part of $t \approx -0.2$ (GeV/c)² in striking similarity with the ρ and ω behavior^(15,21). The real part keeps the same sign in agreement with previous amplitude analyses. On the contrary, the real part of the tensor non-flip amplitude vanishes for $t \approx -0.45$ (GeV/c)² and the imaginary part does exhibit a minimum close to zero in the same region. Here again, this is in agreement with the A_2 amplitudes^(6,8) in KN charge exchange and $\pi^- p \rightarrow \eta n$ reactions.

From these parameters we may extract the SU(3) coupling. The result reads

$$F_0^V = 1.42 \quad F_1^V = 0.204 \quad F_0^T = 1.51 \quad F_1^T = 0.237$$

These values have to be compared to previous value given by C. Michael et al.^(26,34), 1.43 for F_0 and 0.25 for F_1 .

The flip amplitudes are slightly non-exchange-degenerate:

$$\frac{\gamma_1^T - \gamma_1^V}{\gamma_1^T} \sim 10\%$$

both in the Σ and in the Λ case.

In Fig. 4 we also compare with the results of IMB . As discussed above our amplitudes have the same shape in Λ and Σ reactions whereas the amplitudes of IMB do not. Furthermore our amplitudes exhibit much smaller exchange degeneracy breaking. The discrepancy between our amplitudes and those of Ref. 19 at small $(-t)$, we believe, comes from their taking seriously the very large $\pi^- p \rightarrow K^0 \Lambda$ polarization at small t . Due to the constraints of our parameterization, we find smaller $\pi^- p \rightarrow K^0 \Lambda$ polarization at small $(-t)$ (more like in $\pi^+ p \rightarrow K^+ \Sigma^+$). The amplitudes we find exhibit much smaller SU(3) breaking and exchange-degeneracy breaking than found by IMB.

In Fig. 5, we present our total amplitudes for $\pi^- p \rightarrow K^0 \Lambda$ and compare with Ward et al. (3,2). Quantitatively, there are disagreements which stem from the fact that we have included all the data and thus have smoothed amplitudes whereas Ward et al. have solved for the amplitudes algebraically using a limited subset of data supplemented by some reasonable theoretical assumptions (the subset of polarization is data used by Ward et al. includes the already mentioned very large $\pi^- p \rightarrow K^0 \Lambda$ polarization at small t and polarization data at large t that are larger than 1.). The peripheral nature of $\text{Im } H_{++}$ is clearly evident in both analyses.

In Fig. 6, we give our predictions for the spin rotation parameters A and R (37) for both the Λ and the Σ case and compare with IMB. In Fig. 7, we compare related S and T observables (32,38) with a previous amplitude analysis by Ward et al. (32) and with the Strong-Cut-Reggeized Absorption Model (18,38). Our results are intermediate between SCRAM on the one hand and IMB and Ward on the other. The discrepancies between our predictions and the latter are related, as discussed earlier, to how large the $\pi^- p \rightarrow K^0 \Lambda$ polarization data are assumed to be.

In Fig. 8 we give our prediction for $K^-p \rightarrow \eta\Lambda$ and $K^-p \rightarrow \eta'\Lambda$ and compare with the experimental data available^(18,39). We have used $\theta = -11^\circ$ and $S_T = 0.9$ (see Ref. 39) in making our prediction. The agreement is quite satisfactory.

IV. Conclusion.

We have presented here a Regge-pole plus effective-cut parameterization which fits all the experimental data available up to now for the $0^{-1/2^+} \rightarrow 0^{-1/2^+}$ hypercharge exchange reactions.

The good description of these reactions gives strong support to the assumption that vector and tensor exchange amplitudes are universal in meson baryon scattering namely that given the net helicity flip in the s channel the vector (tensor) exchange in hypercharge exchange reaction are strikingly similar to the vector (tensor) exchange in πN and KN reactions. These t dependences can be summarized as follows. The vector $n = 0$ has a peripheral zero in the imaginary part and a real part which has a minimum or vanishes after the imaginary part, whereas the real part of the tensor $n = 0$ vanishes at $(-t) \approx 0.4, 0.5 \text{ (GeV/c)}^2$ and the imaginary part has a minimum or a double zero in the same vicinity.

Both the vector and tensor $n = 1$ amplitudes are Regge like and are approximately exchange degenerate. As for the ρ in πN , the flip K_V^* exhibits the WSNZ at $\alpha(t) = 0$. We find that the SU(3) relations relating Λ and Σ production are satisfied to 10-20%. We find that the effective cuts required have a steep, rather pole-like, effective trajectory.

Further progress in understanding the K_V^* and K_T^* exchanges requires more data. First one needs R and A measurements so that the amplitudes can be extracted with no model dependent assumptions. Second one needs better polarization data, in $\pi^-p \rightarrow K^0\Lambda$ in particular, and in all the exotic reactions. Third, one needs better differential cross section data especially in exotic

reactions and especially for $|t| \geq 1$. Fourth, more data at higher energies are clearly needed to determine more precisely the K_Y^* and K_T^* effective trajectories.

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Figure Captions

- Figure 1: Fits to the differential cross sections. The data are from Refs. 27-30.
- Figure 2: Fits and predictions for the polarization. The data are from Refs. 27-30.
- Figure 3: Illustration of how the data and our fit behave under line reversal near 4 GeV/c, and our predictions for 14 GeV/c.
- Figure 4: The real and imaginary parts of the K_V^* and K_T^* flip and non-flip amplitudes at 4 GeV/c in our analysis and as found by Irving, Barger, and Martin (Ref. 19).
- Figure 5: Comparison of our amplitudes for $\pi^- p \rightarrow K^0 \Lambda$ (—) at 5 GeV/c with the results of Ward et al., ($\frac{1}{2}$), Ref. 32.
- Figure 6: Spin rotation parameters A and R at 5 GeV/c, as predicted by our analysis (—) and as predicted in Ref. 19 (---).
- Figure 7: Spin rotation parameters S and T at 4 GeV/c as predicted by our analysis (—) compared with Ward ($\frac{1}{2}$) and SCRAM (---), Refs. 18 and 38.
- Figure 8: Predictions of our analysis for $K^- p \rightarrow \eta \Lambda$ and $K^- p \rightarrow \eta' \Lambda$.

Figure 1a

Figure 1b

Figure 2a

Figure 2b

LINE-REVERSAL BREAKING

Figure 3

00004402686

4 GeV/c Im H_{++}

4 GeV/c Re H_{++}

Figure 4a

4 GeV/c $\pi - p \rightarrow K^0 \Sigma^0$

Figure 4b

Figure 5

Figure 6

Figure 7

Figure 8

0 0 7 0 4 4 0 2 0 9 0

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