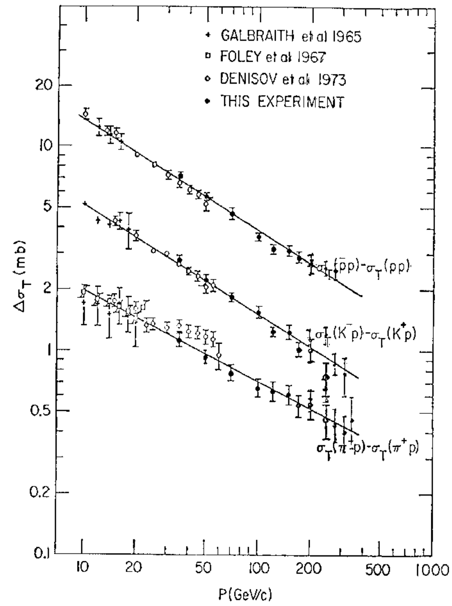

Fig. 2. Antiparticle–particle total cross section differences.

reaches a minimum before rising again.

The simple power law dependence of the antiparticle-particle differences continue to hold at the higher momenta measured here, and shown in Fig. 2. Fitting the data of this experiment with the form $As^{\alpha-1}$, we obtain for the values of α.

The ratio $\sigma_{\pi^- d}/\sigma_{\pi^+ d}$, which should be the unity if charge symmetry is valid, is always consistent with 1, and averages 0.9771 ± 0.0043.

In conclusion, we have measured hadron total cross sections up to 370 GeV/c. The trends observed previously continue to hold. Conclusions drawn on comparisons of the earlier data with various relations given by quark and Regge pole models continue to be valid.

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Charge Exchange, Hypercharge Exchange, and Baryon Exchange Reactions

K. C. MOFFEIT

SLAC

§I. Hypercharge Exchange Reactions

The two pairs of line-reversed reactions: $\pi^+P \to K^+\Sigma^+$; $K^-P \to \pi^-\Sigma^+$ and $\pi^+P \to K^+Y^*(1385)$; $K^-P \to \pi^-Y^*(1385)$ provide experimental test of exchange degeneracy (EXD). The reactions are expected to be dominated by vector and tensor K* exchange. If these Regge-trajectories are exchange degenerate, equal cross sections for the line-reversed reactions are predicted as well as equal and opposite hyperon polarization. If the vector and tensor K* also have the same residues (strong exchange degeneracy), the polarizations are predicted to be zero. Lower energy data has shown violations of these predictions as the cross section for the K^- induced reactions has exceeded that from the π^+ reactions by a factor of two to four.

Recent tests of EXD predictions occur at higher energies and with high statistics. The line reversed reactions are also studied in the same experimental setup. Berglund *et al.* use a missing mass technique to obtain their 7 and 10 GeV/c data at CERN.[1] The ANL–FNAL–SLAC collaboration[2] also use the missing mass method to study the π^+P reactions at 35, 70, and 140 GeV/c and K^-P at 70 GeV/c; only their 70 GeV/c π^-P data is presented at this conference.

The SLAC and Imperial College 7 and 11.5 GeV/c data come from the SLAC 1-meter rapid cycling bubble chamber triggered by electronic detectors (see Fig. 1).[3] An online algorithm uses the 3 millisecond bubble growth time to determine the outgoing track momentum, successful candidates triggered the camera flash lamps.

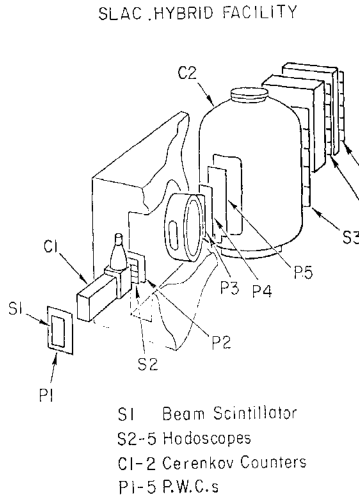

Fig. 1. Perspective drawing of the SLAC Hybrid Facility. The cylindrical bubble chamber is represented in a cut-away drawing of its magnet body. S1–S5 are scintillation hodoscopes. C1 and C2 are Cherenkov counters. P1–P5 are proportional chambers. Steel hadron filters are indicated before S4 and S5.

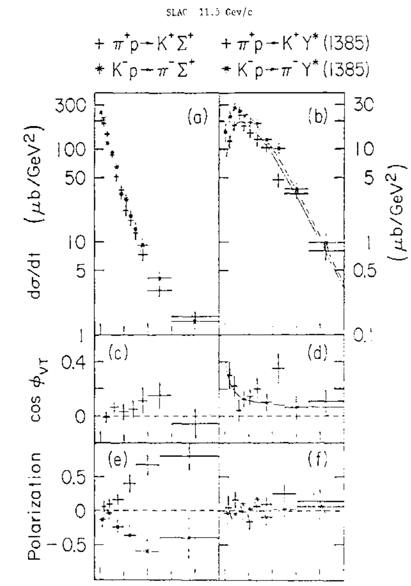

Fig. 2. Comparison of differential cross sections and hyperon polarizations for the two pairs of line-reversed reactions.

$$\langle\cos\theta_{VT}\rangle=\frac{d\sigma/dt(K^-)-d\sigma/dt(\pi^+)}{d\sigma/dt(K^-)+d\sigma/dt(\pi^+)}$$

SLAC data from ref. 3.

For the Σ^+production reactions, differential cross-sections and polarizations show agreement with the predictions of weak EXD as seen in Fig. 2 for the SLAC 11.5 GeV data.[3] The 10 GeV data of Berglund *et al.*[2] show similar behavior, however, at larger momentam transfer small EXD violation are seen. The 7 GeV results show violations of EXD in both experiments. Strong EXD is ruled out at both energies by the non-zero polarizations (see Fig. 2), however, the mirror polarizations support weak EXD.

The invariant mass distribution of the $\pi^+\Lambda$ system from both the π^+ and K^- induced reactions show a prominent peak due to Y* (1385) production. These distributions show the ability of the bubble chamber to isolate this reaction by topology and kinematic fitting over missing mass techniques. The Y*(1385) differential cross-sections seen in Fig. 2b show a forward dip, suggesting that the Y* vertex (as opposed to the Σ vertex) is helicity-flip dominated. The line-reversed pair Y* reactions show significant differences at small $|t|$, however, most of this difference is of kinematic origin: angular momentum conservation forces the two Y* cross sections to turn over at different values of momentum transfer yielding different cross-sections at small $|t|$.[3]

To describe this effect quantitatively, the SLAC group made fits to the differential cross-section using the function:

$$\frac{d\sigma}{dt}=[A_1-A_2(t-t_{\min})]e^{bt}$$

where A_1 and A_2 approximate the helicity non-flip and flip contributions, respectively. The fits give a good description of the data as seen in Fig. 2b. The non-flip parameter A_1 is about 3% of the flip term A_2. The values of A_2 agree within errors for the line-reversed reactions giving confirmation of EXD predictions. They obtain at 11.5 GeV/c

$$\langle\cos\theta_{VT}\rangle=\frac{A_2(K^-P)-A_2(\pi^+P)}{A_2(K^-P)+A_2(\pi^+P)}$$
$$=0.05\pm0.10.$$

The Y*(1385) has polarization consistent with zero over the entire t-range for both reactions as seen in Fig. 2f. This agrees with strong EXD: however, the Stodolsky–Sakurai[4] or Additive Quark Models[5] predict the same behavior.

Data on the reactions $\pi^+P\to K^+\Sigma^+$ and $\pi^+P\to K^+Y^{*+}$ have been reported using the Fermilab Single Arm Spectrometer Facility at 70 GeV/c.[2] For $-t<0.1$ (GeV/c)^2 the Y* (1385) signal is much smaller than the Σ^+, whereas for larger t the two signals become comparable (see Fig. 3). Their results show

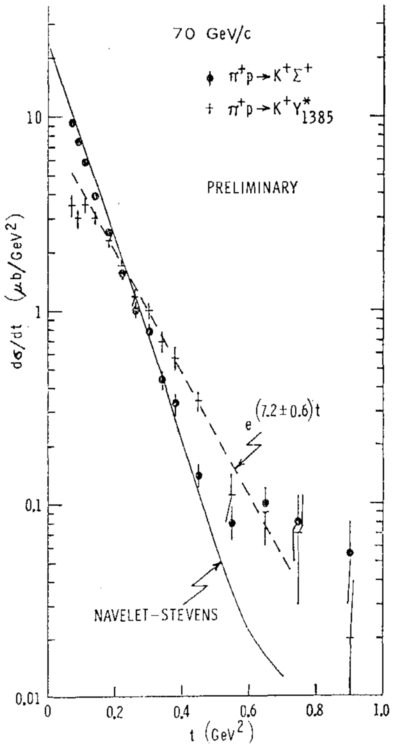

Fig. 3. Preliminary differential cross section at 70 GeV/c with exponential fit to the Y* data between $-t$=0.2 and 0.5 (GeV/c)^2 and the prediction of Navelet and Stevens[6] for Σ^+ production. Data from ref. 2.

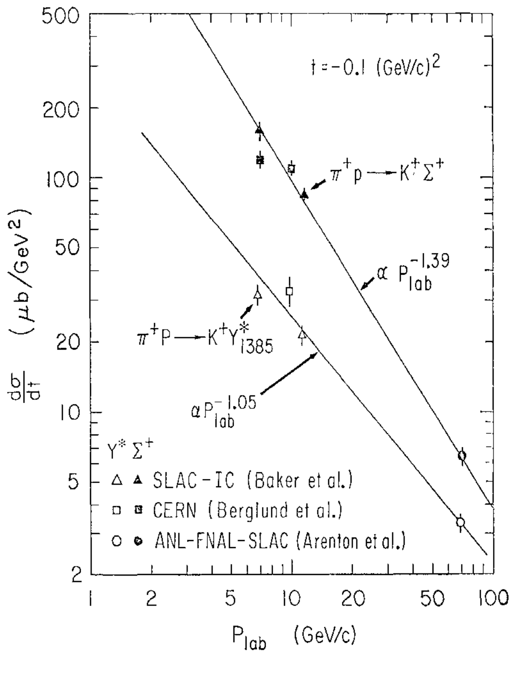

Fig. 4. P_{lab} dependence of the Σ and Y* production at $t=-0.1$ (GeV/c)^2. Data from refs. 1–3.

positive Σ^+ polarization that appear to be more positive than the Navelet–Stevens[6] predictions but very similar to the 7 and 11.6 GeV polarizations measured by SLAC–Imperial College.[3]

Figure 4 shows the energy dependence of the π^+P reactions at $-t$=0.1 (GeV/c)^2. We see a faster falloff for the Σ^+ reaction than for the Y* reaction.

§II. Amplitude Analysis of Y*(1385) Production

SLAC and Imperial College measure for the first time in one detector the complete decay angular distribution on $Y^* \to \Lambda\pi$, $\Lambda \to P\pi^-$ in the π^+P and K$^-$P line reversed reactions.[7] The results for the four measureable transversity amplitudes are shown in Fig. 5 together

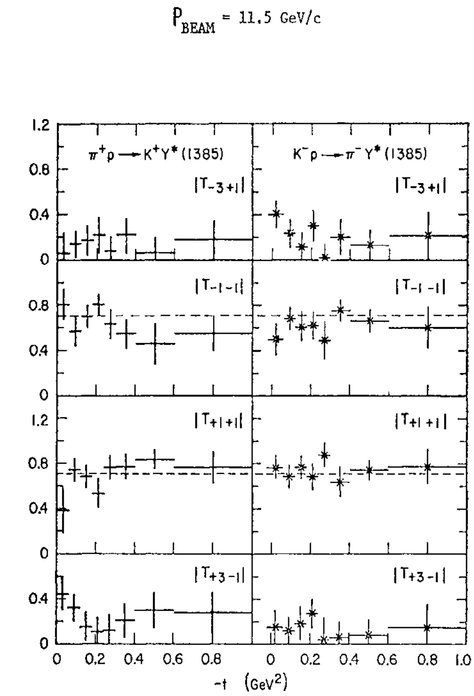

Fig. 5. Absolute values of the Y*(1385) transversity amplitudes as a function of momentum transfer. The dashed lines are quark model predictions. Data from SLAC hybrid facility of ref. 7.

with the predictions of the additive quark model[5] and Stodolsky–Sakurai[4] models. In general, the data agree with these prediction. However, the only significant non-zero double-flip values are at small t similar to what has been observed at 4.2 GeV/c in K$^-$P interactions.[8] This effect may be associated with a finite helicity non-flip contribution to the Y*(1385) vertex. At $t=t_{\min}$ all helicity flip amplitudes go to zero and any remaining non-flip contributions forces the transversity amplitudes to the values:

$$|T_{-3+1}|=|T_{+3-1}|=\sqrt{\frac{3}{8}}\,;$$

$$|T_{+1+1}|=|T_{-1-1}|=\sqrt{\frac{1}{8}}$$

in the forward direction. The trend of the data is in qualitative agreement with these results.

§III. Comparison of Pseudoscalar and Vector Meson Production in Hypercharge Exchange Reactions

In addition to the K*(890) and K**(1420) exchanges, the unnatural parity K exchange is allowed in the reaction $\pi^+P\rightarrow K^*(890)\ Y^+$ and $K^-P\rightarrow\rho^-Y^+$ where Y^+ is either Σ^+ and/or a Y*(1385). The SLAC–Imperial College data at 7 and 11.5 GeV/c find similar behavior for the vector meson and pseudoscalar production.[9] Namely, the Σ^+ production is forward peaked, the Y*(1385) shows a turnover in the forward direction, and the cross sections are approximately the same at 11.5 GeV/c for the line reversed pairs. The ABBCCLV Collaboration have measured the energy dependence and find similar behavior in the 0^- and 1^- production processes.[10] SLAC-IC find that the Σ^+ polarizations show the mirror reflection between the π^+P and K^-P reactions.

These results suggest that the K* and K** exchanges dominate the vector meson production and the K-exchange is weak. Indeed this is the case. From the vector meson decay the SLAC-IC data show dominance of natural parity exchange ($\sim 70\%$).[9]

§IV. Quark Model Relations in Hypercharge Exchange Reactions

The ACNO collaboration[11] has studied the reaction $K^-P\rightarrow\pi^0\Lambda(1520)$ at 4.2 GeV/c. The differential cross section shows a turnover in the forward direction suggesting as in Y*(1385) production dominance of helicity flip amplitudes. The backward production for $\Lambda(1520)$ is larger than for the Λ. They find similar violations of Exchange Degeneracy predictions in $\Lambda(1520)$ production as occured at 4.2 GeV/c in the Σ^+ and Y*(1385) case; the K^-P cross sections are larger than the π^-P results.

The quark model using the conventional mixing of the pseudoscalar mesons leads to the strangeness exchange sum rule for any hyperon Y:

$$\frac{d\sigma}{dt}(K^-P\rightarrow\eta Y)+\frac{d\sigma}{dt}(K^-P\rightarrow\eta' Y)$$
$$=\frac{d\sigma}{dt}(K^-P\rightarrow\pi^0 Y)+\frac{d\sigma}{dt}(\pi^-P\rightarrow K^0 Y)$$
$$(18\pm3)\mu b+(16\pm4)\mu b$$
$$<(38\pm5)\mu b+(18\pm4)\mu b.$$

Their results show that the strangeness exchange sum rule also fails for the $\Lambda(1520)$.[11]

It is well known that serious disagreement occurs for the sum rule:

$$\frac{d\sigma}{dt}(K^-P\rightarrow M^0\Lambda)$$
$$=3\left[\frac{d\sigma}{dt}(K^-P\rightarrow M^0\Sigma^0)+\frac{d\sigma}{dt}(K^-P\rightarrow M^0Y^*)\right]$$

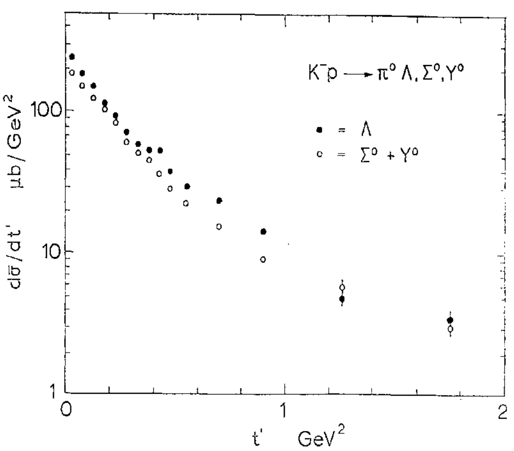

Fig. 6. Differential cross section of the reaction $K^-P\rightarrow\eta^0\Lambda$ and the sum of the differential cross sections of the reactions $K^-P\rightarrow\pi^0\Sigma^0$ and $K^-P\rightarrow\pi^0Y^0$. Data from ACNO ref. 11.

obtained using the additivity hypothesis and the SU(6) baryon wave function at the baryon vertex. The ACNO collaboration study systematics of the breaking of the SU(6) predictions.[12] As seen in Fig. 6, they find strong disagreement at all t by about a factor 3. However, they obtain the correct prediction of polarization which implies that the additivity assumption and the spin–isospin correlations in the spectator diquark are valid. This means that the SU(6) baryon wave functions may be the cause of the disagreement.

§V. Charge-Exchange Reactions

The differential cross section of the reaction $\pi^-P\rightarrow\eta^0N$, $\eta^0\rightarrow\gamma\gamma$ for 3.3 and 4.75 GeV/c pions was measured for $-t<0.3\ (\text{GeV}/c)^2$ by Astvatsaturov *et al.*.[13] A marked minimum

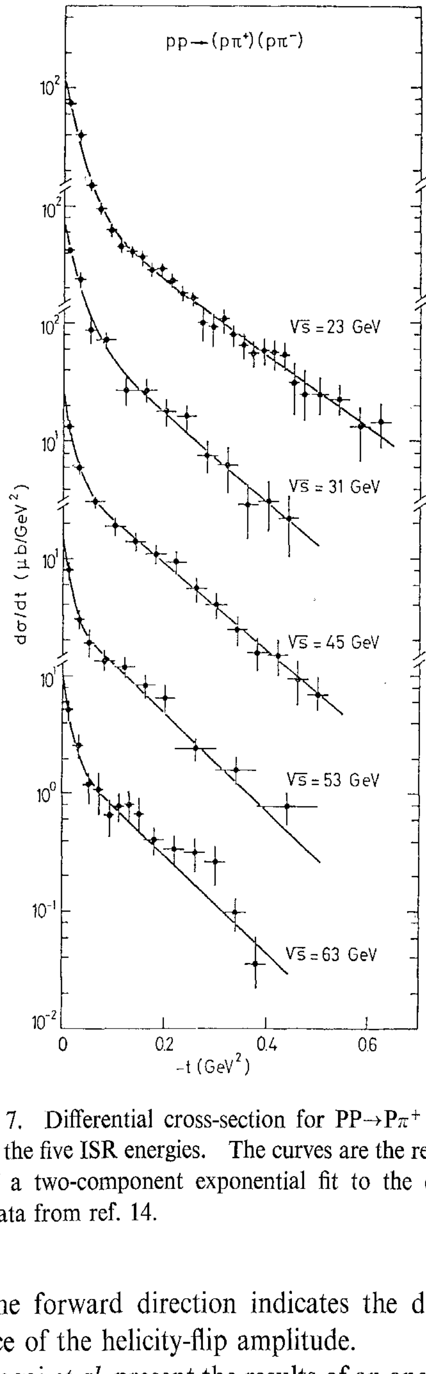

Fig. 7. Differential cross-section for $PP \rightarrow P\pi^+ P\pi^-$ at the five ISR energies. The curves are the results of a two-component exponential fit to the data. Data from ref. 14.

in the forward direction indicates the dominance of the helicity-flip amplitude.

Goggi *et al.* present the results of an analysis of charge-exchange double dissociation in proton-proton collisions at the CERN Intersecting Storage Rings.[14] The data, obtained with the Split-Field Magnet detector, cover the entire ISR energy range between $\sqrt{s}=23$ GeV and $\sqrt{s}=63$ GeV at five energies. Double resonance production is observed in the $\Delta^{++}\Delta^0$ and $\Delta^{++}N^0(1688)$ final states. The differential cross sections seen in Fig. 7 show a forward peak typical of absorbed pion exchange decreasing as $s^{-1.81\pm0.06}$, followed by a much gentler exponential behavior associated with a trajectory typical of ρ–A_2 exchange.

§VI. Baryon Exchange Reactions

Purdue and Toronto[15] present preliminary results on *u*-channel proton production in the reaction $\pi^+P \rightarrow P\pi^+\pi^+\pi^-$ at 11.5 GeV/*c*. The data were obtained in the SLAC Hybrid Facility by triggering the flash lamps on the indication of a forward heavy particle. The reaction has a cross section of approximately 10 μb of which 30% contains a $\Delta^{++}(1232)$ in the $\pi^+_F P$ combination. Although they see no evidence for backward A production, the channels exhibit strong baryon and meson resonance production.

Acknowledgements

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A 1 Diffractive Dissociation Processes

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Diffractive dissociation processes are most readily and convincingly isolated at the highest available energies, namely $\sqrt{s}\gtrsim$ a few hundred GeV. This has been demonstrated in work from ISR and Fermilab on nucleon–nucleon reactions that has been studied by the missing mass recoil technique, *e.g.*, gas jet work and detailed studies have been reported at previous conferences on the dynamical structure of explicit low multiplicity channels, *e.g.*, $p\rightarrow p\pi^+\pi^-$, $n\rightarrow p\pi^-$ and $p\rightarrow n\pi^+$. It is somewhat suprising to contemplate the paucity of data on the high energy dissociation of mesons. Certainly, the techniques and beams have been available for a long time at Fermilab. Undoubtedly, this area of physics has suffered as a consequence of frenzied and largely unrequited efforts at new particle searching. The author stands exposed as a flagrant culprit.

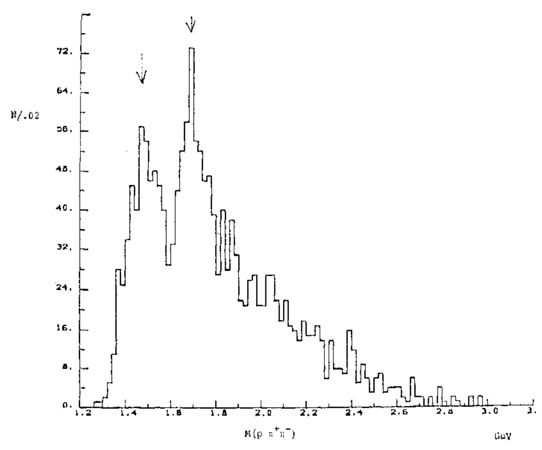

Fig. 1. The $P\pi^+\pi^-$ mass distribution for events with $\cos\theta_1<0$ and $\cos\bar{\theta}_1>0$.

The Amsterdam group (paper 401) has reported on the analysis of 8192 events of the type $\bar{p}p\rightarrow\bar{p}p\pi^+\pi^-$ recorded in the 2m CERN HBC at 7.23 GeV/c. Diffractive dissociation has been isolated from double resonance production by cuts applied to angular parameters. Figure 1 shows a selected histogram which displays the now canonical dissociation mass spectrum featuring peaks at 1450 and 1690 MeV.

The Aachen–Berlin–CERN–London–Vienna Collaboration has contributed paper 97 which describes a method for isolating diffractive mass spectra in the low energy regime. The method is applied to data on K^-p interactions at 10 and 16 GeV/c.

The Amsterdam–CERN–Cracow–Munich–Oxford–Rutherford Collaboration, paper 696, has reported the results of an experiment to study the reaction, $\pi^-p\rightarrow\pi^-\pi^-\pi^+p$ at a beam momentum of 93 GeV/c. A 3 body phase shift analysis along the lines pioneered by Ascoli has been applied to the data and the $A_1(1^+)$, $A_2(2^+)$ and $A_3(2^-)$ components have been isolated. Figures 2 a, b, c show the composite momentum dependence of these major terms. It can be seen that the A_1 and A_3 dependencies on momentum are comparable and in fact, may well be flat above $\sim$30 GeV/c.