where we have introduced the usual spherical and quadrupole form factors of the deuteron,

$$S_0(\vec{\Delta}) = \int d^3p\,[\varphi_S^*(\vec{p})\varphi_S(\vec{\Delta}-\vec{p}) + \varphi_D^*(\vec{p})\varphi_D(\vec{\Delta}-\vec{p})]$$

$$= \int_0^\infty dr\,[u^2(r) + w^2(r)]\,j_0(\Delta r)$$

$$S_2(\vec{\Delta}) = 2^{1/2}\int_0^\infty dr\,w(r)[u(r) - 8^{1/2}w(r)]\,j_2(\Delta r)\,.$$

It may be noted that the differential cross section (26) contains, via the quadrupole form factor, a dependence on the direction of the momentum transfer $\hat{\Delta}$ relative to the vector $\vec{D}_-$, i.e., relative to whatever vectors describing the particles a, b are used to construct the amplitude. (For example, if b is a vector meson, $\vec{D}_-$ will be proportional to its polarization vector.) If the states of a and b are summed over, this dependence will be replaced by an appropriately incoherent sum.

Multiple scattering corrections to the amplitudes C_- and $\vec{D}_-$ can be calculated via the Glauber theory, although one may question whether that method properly includes all inelastic intermediate states for breakup scattering. If it is assumed that the only important corrections arise from (a) elastic scattering of a before the breakup, and (b) elastic scattering of b after the breakup, the results will be essentially those obtained in an earlier paper[7] neglecting spin, isospin, and symmetrization effects.

*Work performed in part in the Ames Laboratory of the U. S. Atomic Energy Commission. Contribution No. 3064.

[1]W. Lee, UCRL Report No. UCRL-9691, 1961 (unpublished); S. Fernbach, T. A. Green, and K. M. Watson, Phys. Rev. 84, 1084 (1951). Others who have studied these reactions have generally based their work upon these two sources.

[2]Including final-state interactions to alter the spatial wave function would not significantly alter our results.

[3]We are working in the deuteron's rest frame.

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PHYSICAL REVIEW D VOLUME 5, NUMBER 11 1 JUNE 1972

Application of the New Interference Model to the Meson-Baryon Hypercharge-Exchange Reactions

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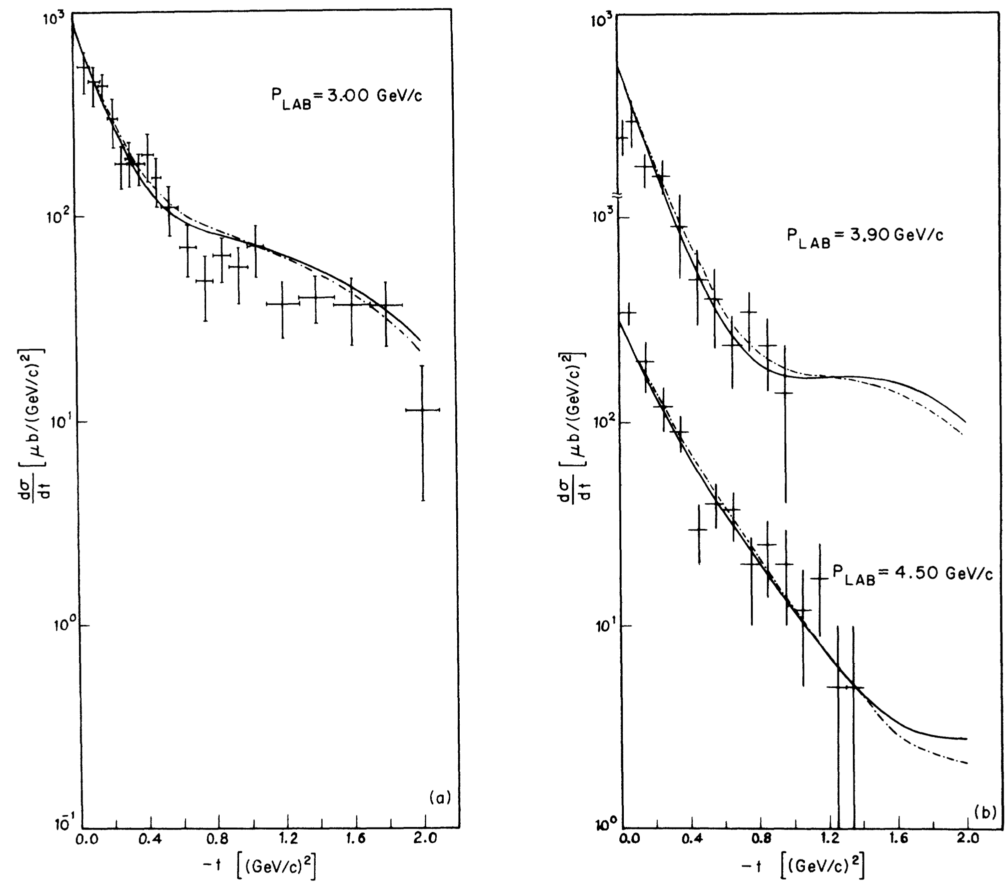
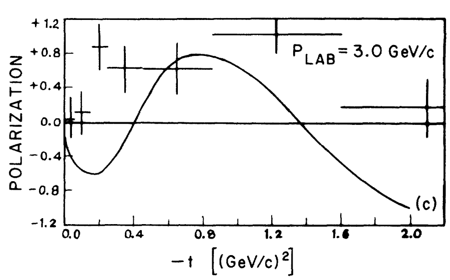
The hypercharge-exchange reactions $K^-n\to\pi^-\Lambda^0$, $K^-p\to\pi^0\Lambda^0$, $\pi^-p\to K^0\Lambda^0$, $K^-n\to\pi^-\Sigma^0$, $K^-p\to\pi^-\Sigma^+$, $\pi^-p\to K^0\Sigma^0$, and $\pi^+p\to K^+\Sigma^+$ are studied within the framework of the new interference model. It is found that the differential cross section and polarization can be predicted in reasonable agreement with experiments in the intermediate momentum range.

I. INTRODUCTION

Several attempts[1-3] have been made to explain the observed differential cross-section and polarization data for the various hypercharge-exchange $0^-\frac{1}{2}^+\to 0^-\frac{1}{2}^+$ reactions. In the Regge-model approach[1] the possible t-channel Regge poles $K^*(890)$ $J^P=1^-$ and $K^{**}(1420)$ $J^P=2^+$ are taken as nondegenerate; trajectory functions are modified, and a cross-over term is introduced to obtain reasonable success, with eight parameters in the cross-section formula. Absorptive peripheral models[2,3] have been tried with and without exchange degeneracy. By using trajectory parameters which are different from those determined from a Chew-Frautschi plot acceptable fits have been obtained.

In the intermediate momentum region, it has been shown[4,5] that the new interference model of Coulter *et al.*,[6] which is free from double-counting errors, gives a satisfactory explanation both for angular distribution and polarization. In this paper the calculations have been extended to the following hypercharge-exchange reactions in the intermediate momentum region:





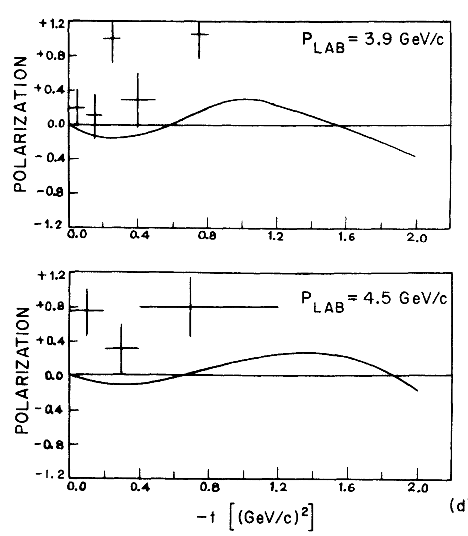


FIG. 1. The production angular distribution for the reaction $K^-n \to \pi^-\Lambda^0$ at the incident kaon momenta of (a) 3.00, (b) 3.90, and 4.50 GeV/c, and the polarization for the same reaction at incident kaon momenta of (c) 3.00, (d) 3.90, and 4.50 GeV/c. The solid-line and dash-dotted curves are our predictions when the residue functions of this paper [Eq. (14)] and those of Ref. 5 are used, respectively. The experimental data have been taken from Barloutaud *et al.* (Ref. 10) for 3.00 GeV/c, from Crennell *et al.* (Ref. 11) for 3.90 GeV/c, and from Yen *et al.* (Ref. 12) for 4.50 GeV/c.

$K^- n \to \pi^- \Lambda^0$, (1)

$K^- p \to \pi^0 \Lambda^0$, (2)

$\pi^- p \to K^0 \Lambda^0$, (3)

$K^- n \to \pi^- \Sigma^0$, (4)

$K^- p \to \pi^- \Sigma^+$, (5)

$\pi^- p \to K^0 \Sigma^0$, (6)

$\pi^+ p \to K^+ \Sigma^+$. (7)

In our calculations we have assumed strong exchange degeneracy of the $K^*(890)$ and $K^{**}(1420)$ trajectories and evaluated the trajectory parameters from the Chew-Frautschi plot.

II. SCATTERING AMPLITUDES

The Regge and resonance contributions can be written as follows:

$$A'_{\text{Regge}} = \frac{\beta_1}{\Gamma(\alpha)} \frac{1}{\sin\pi\alpha} \left(\frac{s}{s_0}\right)^{\alpha}, \tag{8a}$$

$$B_{\text{Regge}} = \frac{\beta_2}{\Gamma(\alpha)} \frac{1}{\sin\pi\alpha} \left(\frac{s}{s_0}\right)^{\alpha-1}, \tag{8b}$$

$$A'_{\text{resonance}} = 4\pi\left(\frac{|\vec{q}_1|}{|\vec{q}_2|}\right)^{1/2} \left(\frac{W+\bar{m}}{(E_1+m_1)^{1/2}(E_2+m_2)^{1/2}} f_1 - \frac{W-\bar{m}}{(E_1-m_1)^{1/2}(E_2-m_2)^{1/2}} f_2\right) + \frac{s-u+\Delta}{4\bar{m}^2-t}\,\bar{m} B_{\text{resonance}}, \tag{9a}$$

$$B_{\text{resonance}} = 4\pi\left(\frac{|\vec{q}_1|}{|\vec{q}_2|}\right)^{1/2} \left(\frac{1}{(E_1+m_1)^{1/2}(E_2+m_2)^{1/2}} f_1 + \frac{1}{(E_1-m_1)^{1/2}(E_2-m_2)^{1/2}} f_2\right), \tag{9b}$$

TABLE I. The decay widths and elasticities of resonances.[a]

Resonance	J^P	Γ_{used} (GeV)	Γ_{exp} (GeV)	$100\times(\Gamma_1\Gamma_2)^{1/2}_{\text{used}}$ (GeV)	$100\times(\Gamma_1\Gamma_2)^{1/2}_{\text{exp}}$ (GeV)	ϕ
$\Sigma(1670)$	$\frac{3}{2}^-$	0.050	0.050	0.80	0.80	+
$\Sigma(1690)$	$\frac{1}{2}^-$	0.130	0.062–0.130	2.40	...	–
$\Sigma(1750)$	$\frac{1}{2}^-$	0.065	0.050–0.080	3.40	...	–
$\Sigma(1765)$	$\frac{5}{2}^+$	0.100	~0.120	2.57	~3.00	–
$\Sigma(1880)$	$\frac{1}{2}^+$	0.200	0.170–0.222	5.00	...	–
$\Sigma(1915)$	$\frac{5}{2}^+$	0.080	0.070	0.70	0.60	–
$\Sigma(1940)$	$\frac{3}{2}^-$	0.240	0.200–0.280	1.70	...	+
$\Sigma(2030)$	$\frac{7}{2}^+$	0.130	0.100–0.170	3.40	2.50–4.25	+
$\Sigma(2080)$	$\frac{3}{2}^+$	0.090	0.087–0.250	0.57	...	–
$\Sigma(2100)$	$\frac{7}{2}^-$	0.070	0.070–0.135	0.31	...	+
$\Sigma(2250)$	$\frac{7}{2}^-$	0.100	0.100–0.230	0.27	...	–
$\Sigma(2595)$	$\frac{9}{2}^+$	0.140	~0.140	1.00	...	–
$\Sigma(3000)$	$\frac{15}{2}^+$	0.140	...	0.31	...	+

[a]The experimental values have been quoted from the table of the Particle Data Group (Ref. 9).

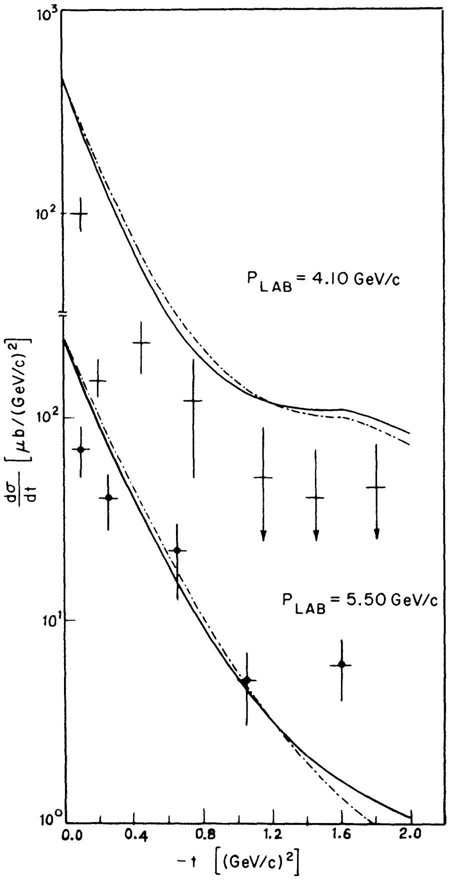


FIG. 2. The production angular distribution for the reaction $K^- p \to \pi^0 \Lambda^0$ at the incident kaon momenta of 4.10 and 5.50 GeV/c. The solid and dash-dotted curves are our predictions when the residue functions of this paper [Eq. (14)] and those of Ref. 5 are used, respectively. The experimental data have been taken from Hodge (Ref. 13).

with

$$\Delta = \frac{(m_1 - m_2)(\mu_1^{\,2} - \mu_2^{\,2})}{2\bar{m}},$$

$$f_1 = \sum_{l=0}^{\infty} [f_{l+} P_{l+1}{}'(\cos\theta) - f_{l-} P_{l-1}{}'(\cos\theta)],$$

$$f_2 = \sum_{l=1}^{\infty} (f_{l-} - f_{l+}) P_l{}'(\cos\theta).$$

In Eqs. (8) β_1 and β_2 are the spin-nonflip and spin-flip residue functions, respectively; α is the Regge exchange-degenerate $K^*(890)$ and $K^{**}(1420)$ trajectory parameter, and s_0 is the scaling factor. In Eqs. (9) $|\vec{q}_1|$ and $|\vec{q}_2|$ are the initial and final center-of-mass momenta, respectively; E_1 and E_2 are the initial and final baryon center-of-mass energies, respectively; m_1 (m_2) is the mass of the initial (final) baryon, $\bar{m}$ is the average of the two external baryon masses, μ_1 (μ_2) is the mass of the initial (final) meson; s, t, u are the usual Mandelstam variables, and θ is the center-of-mass scattering angle between the initial and final mesons. In writing the Regge amplitudes, we have dropped the signature-term part which in the new interference model is replaced by the sum of the s-channel resonances.

In the new interference model, the spin-nonflip and the spin-flip amplitudes are given by the sum of the corresponding Regge and resonance contributions (8) and (9).

The partial-wave amplitudes can be obtained by using the Breit-Wigner formula for the resonance scattering:

$$f_{l\pm} = \frac{1}{2|\vec{q}_1|} \frac{\phi(\Gamma_1\Gamma_2)^{1/2}}{(W_r - W) - \frac{1}{2} i\Gamma}. \tag{10}$$

Here Γ is the total width of the resonance, Γ_1 and Γ_2 are the partial decay widths in the incoming

TABLE II. The decay widths and elasticities of resonances.[a]

Resonance	J^P	Γ_{used} (GeV)	Γ_{exp} (GeV)	$100\times(\Gamma_1\Gamma_2)^{1/2}_{used}$ (GeV)	$100\times(\Gamma_1\Gamma_2)^{1/2}_{exp}$ (GeV)	ϕ
$N(1670)$	$\frac{5}{2}^-$	0.105	0.105–0.175	0.22	0.22–0.36	+
$N(1688)$	$\frac{5}{2}^+$	0.105	0.105–0.180	0.26	0.26–0.43	+
$N(1700)$	$\frac{1}{2}^-$	0.100	0.100–0.400	1.87	1.87–7.48	+
$N(1780)$	$\frac{1}{2}^+$	0.270	0.270–0.450	1.57	1.57–2.62	+
$N(1860)$	$\frac{3}{2}^+$	0.310	0.310–0.450	6.27	6.27–9.06	+
$N(2190)$	$\frac{7}{2}^-$	0.250	0.270–0.325	0.35	0.35–0.49	−
$N(2650)$	$\frac{11}{2}^-$	0.300	0.300–0.400	0.37	0.37–0.49	−

[a] The experimental values have been quoted from the table of the Particle Data Group (Ref. 9).

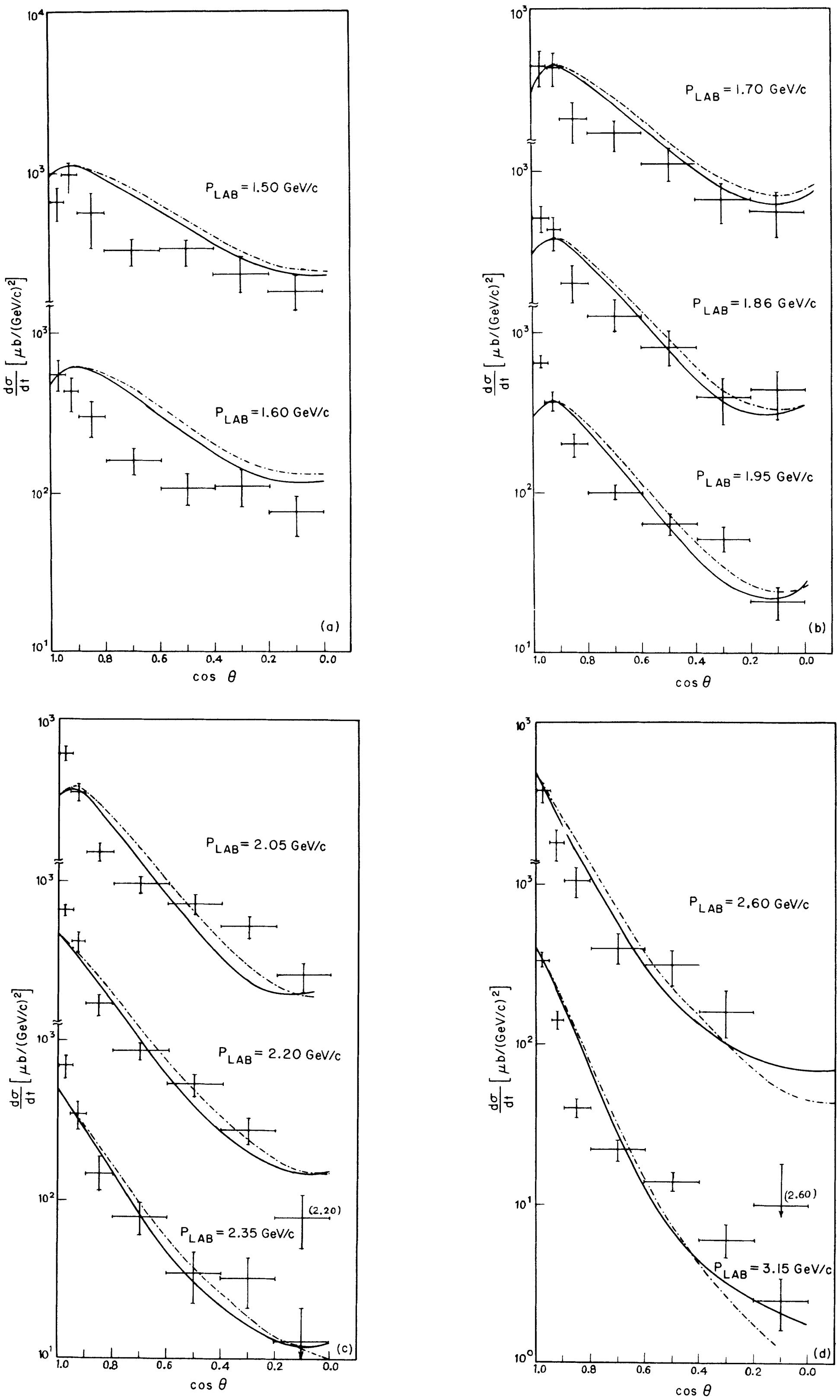


FIG. 3. *(continued on next page)*

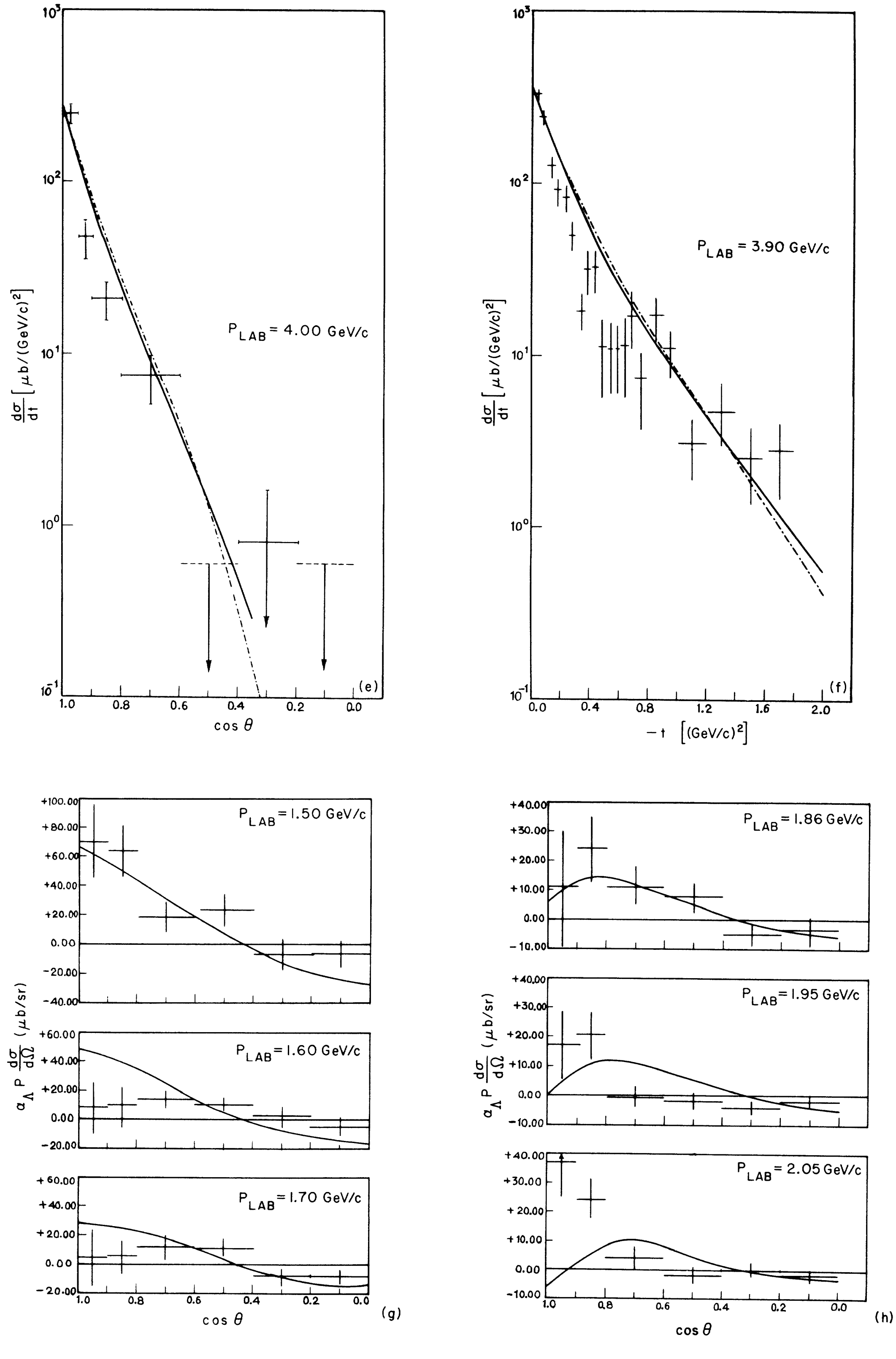


FIG. 3. *(continued on next page)*

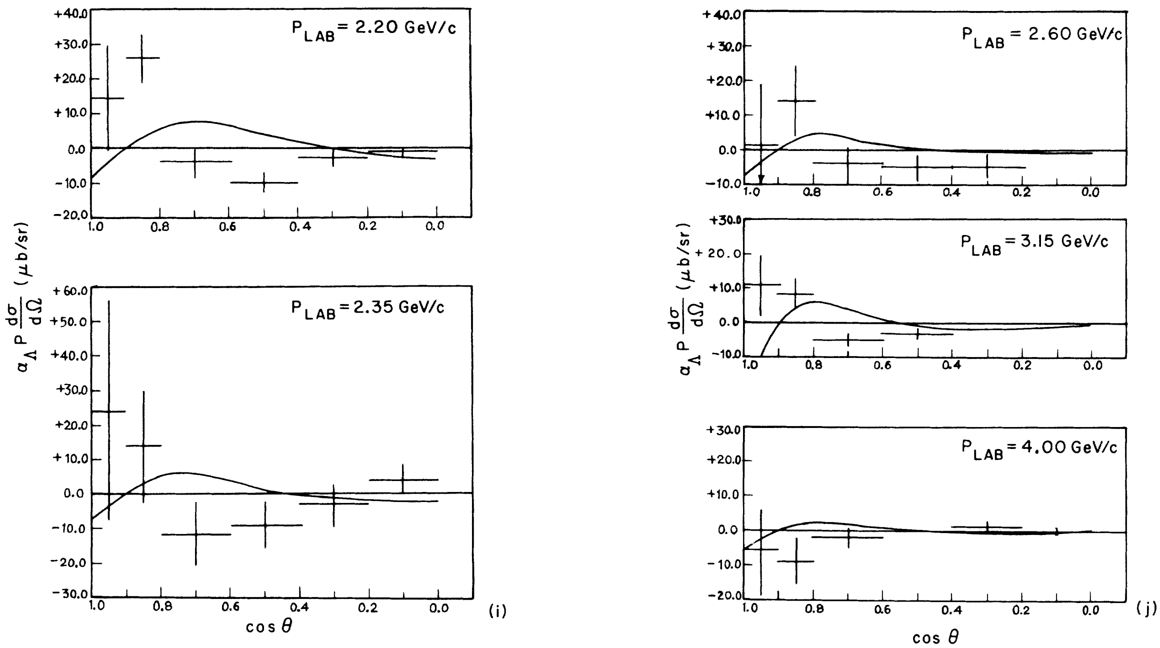


FIG. 3. The production angular distribution for the reaction $\pi^- p \to K^0 \Lambda^0$ at the incident pion momenta of (a) 1.50 and 1.60 GeV/c; (b) 1.70, 1.86, and 1.95 GeV/c; (c) 2.05, 2.20, and 2.35 GeV/c; (d) 2.60 and 3.15 GeV/c; (e) 4.00 GeV/c; (f) 3.90 GeV/c; and the polarization for the same reaction at the incident pion momenta of (g) 1.50, 1.60, and 1.70 GeV/c; (h) 1.86, 1.95, and 2.05 GeV/c; (i) 2.20 and 2.35 GeV/c; (j) 2.60, 3 .15, and 4.00 GeV/c. The solid-line and dash-dotted curves are our predictions when the residue functions of this paper [Eq. (14)] and those of Ref. 5 are taken, respectively. The polarization plots in Figs. 3(g), 3(h), 3(i), and 3(j) are $\alpha_\Lambda P d\sigma/d\Omega$ vs $\cos\theta$, where $\alpha_\Lambda = 0.66$, P is the polarization, and $d\sigma/d\Omega$ is the angular distribution. The experimental data have been taken from Dahl *et al.* (Ref. 14), except those at momentum 3.90 GeV/c which have been taken from Abramovich *et al.* (Ref. 15).

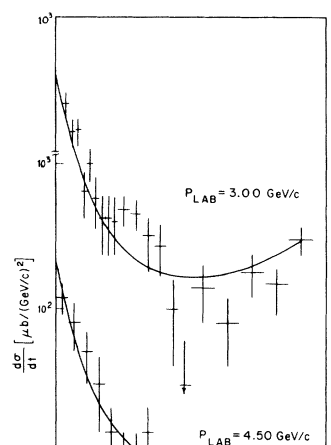


FIG. 4. The production angular distribution for the process $K^- n \to \pi^- \Sigma^0$ at the incident kaon momenta of 3.00 and 4.50 GeV/c. The experimental data have been taken from Barloutaud *et al.* (Ref. 10) and from Yen *et al.* (Ref. 12), respectively.

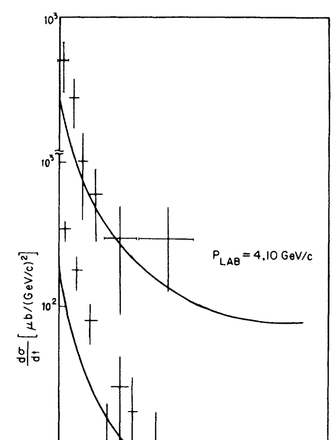


FIG. 5. The production angular distribution for the process $K^- p \to \pi^- \Sigma^+$ at the incident kaon momenta of 4.10 and 5.50 GeV/c. The experimental data have been taken from Loos *et al.* (Ref. 16).

TABLE III. The decay widths and elasticities of resonances.[a]

Resonance	J^P	Γ_{used} (GeV)	Γ_{exp} (GeV)	$100\times(\Gamma_1\Gamma_2)^{1/2}_{used}$ (GeV)	$100\times(\Gamma_1\Gamma_2)^{1/2}_{exp}$ (GeV)	ϕ
$\Sigma(1670)$	$\frac{3}{2}^-$	0.050	0.050	0.45	...	+
$\Sigma(1750)$	$\frac{1}{2}^-$	0.080	0.050–0.080	0.88	...	−
$\Sigma(1765)$	$\frac{5}{2}^-$	0.120	~0.120	0.80	0.80	−
$\Sigma(1915)$	$\frac{5}{2}^+$	0.070	0.070	0.57	...	−
$\Sigma(1940)$	$\frac{3}{2}^-$	0.240	0.200–0.280	0.59	...	+
$\Sigma(2030)$	$\frac{7}{2}^+$	0.170	0.100–0.170	1.44	0.45–1.96	−
$\Sigma(2070)$	$\frac{5}{2}^+$	0.100	0.140	0.45	...	−
$\Sigma(2100)$	$\frac{7}{2}^-$	0.070	0.070–0.135	0.41	...	−
$\Sigma(2250)$	$\frac{7}{2}^-$	0.100	0.100–0.230	0.09	...	+
$\Lambda(1520)$	$\frac{3}{2}^-$	0.016	0.016–0.018	0.70	0.70–0.79	+
$\Lambda(1670)$	$\frac{1}{2}^-$	0.038	0.015–0.038	1.14	0.45–1.14	−
$\Lambda(1690)$	$\frac{3}{2}^-$	0.027	0.027–0.085	0.94	0.94–2.94	−
$\Lambda(1750)$	$\frac{1}{2}^+$	0.300	0.030–0.300	3.67	...	−
$\Lambda(1815)$	$\frac{5}{2}^+$	0.064	0.064–0.100	1.67	1.67–2.61	−
$\Lambda(1830)$	$\frac{5}{2}^-$	0.150	0.074–0.150	2.60	1.30–2.60	−
$\Lambda(1860)$	$\frac{3}{2}^+$	0.080	0.020–0.080	1.13	...	−
$\Lambda(1870)$	$\frac{1}{2}^-$	0.100	0.040–0.100	3.80	...	−
$\Lambda(2010)$	$\frac{3}{2}^-$	0.130	0.130	0.07	...	−
$\Lambda(2020)$	$\frac{7}{2}^+$	0.160	0.160	0.05	...	−
$\Lambda(2100)$	$\frac{7}{2}^-$	0.060	0.060–0.140	0.67	0.67–1.57	+
$\Lambda(2110)$	$\frac{5}{2}^+$	0.185	0.185	0.09	...	−
$\Lambda(2350)$	$\frac{9}{2}^+$	0.140	0.140–0.324	0.17	...	−

[a] The experimental values have been quoted from the table of the Particle Data Group (Ref. 9).

and outgoing channels, respectively, ϕ is the SU(3) relative sign of the resonant amplitude, W_r is the mass of the resonance, and the c.m. energy W has been used for $\sqrt{s}$.

In terms of A' and B, the differential cross-section[7] and polarization[8] are given by

$$\frac{d\sigma}{dt}=\frac{1}{64\pi s|\vec{q}_1|^2}\left((4\bar{m}^2-t)|A'|^2+\frac{4s|\vec{q}_1|^2|\vec{q}_2|^2\sin^2\theta}{4\bar{m}^2-t}|B|^2\right), \tag{11}$$

$$P\frac{d\sigma}{dt}=-\frac{|\vec{q}_1|}{|\vec{q}_2|}\frac{1}{16\pi W}\sin\theta\,\mathrm{Im}(A'B^*). \tag{12}$$

In our calculations we have taken the scaling factor s_0 as 1 GeV^2. The trajectory α is given by the Chew-Frautschi plot,

$$\alpha=0.24+0.9t. \tag{13}$$

The residue functions are taken to be:

For the Λ class of reactions,

$$\beta_1=30e^{0.5t}+10e^{-0.8t}\ \mathrm{GeV}^{-1},\quad \beta_2=-250e^{0.5t}-50e^{-0.8t}\ \mathrm{GeV}^{-2}. \tag{14}$$

For the Σ class of reactions,

$$\beta_1=17e^{5t}+10e^{-1.45t}\ \mathrm{GeV}^{-1},\quad \beta_2=-140e^{5t}-38e^{-1.45t}\ \mathrm{GeV}^{-2}. \tag{15}$$

For the Λ class of reactions the constant residue functions ($\beta_1=40$ GeV^{-1}, $\beta_2=-300$ GeV^{-2}) of Ref. 5 give equally good results. For the Σ class of reactions, the first term in β is needed to account for the steepness of the differential cross-section

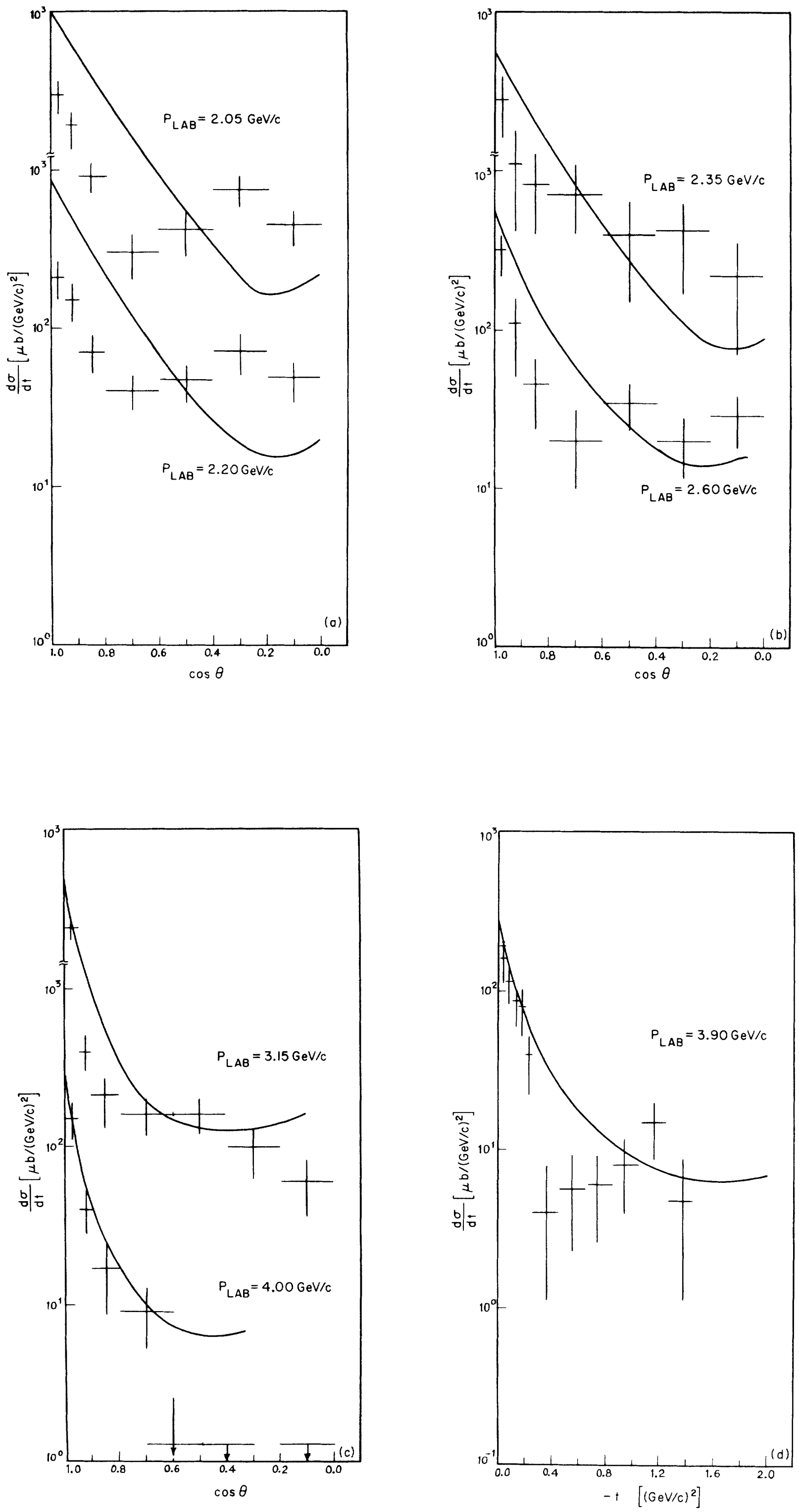


FIG. 6. The production angular distribution for the process $\pi^- p \to K^0 \Sigma^0$ at the incident pion momenta of (a) 2.05 and 2.20 GeV/c; (b) 2.35 and 2.60 GeV/c; (c) 3.15 and 4.00 GeV/c; and (d) 3.90 GeV/c. The experimental data have been taken from Dahl *et al.* (Ref. 14) for 2.05, 2.20, 2.35, 2.60, 3.15, and 4.00 GeV/c and from Abramovich *et al.* (Ref. 15) for 3.90 GeV/c.

data at small $|t|$, and the second term is needed for the flattening and slight rise of the data at large $|t|$.

III. RESULTS AND DISCUSSIONS

Using resonance parameters taken from Particle Data Tables,[9] we have calculated differential cross sections and polarizations for the various reactions, for comparison with experimental data.[10–19]

(A) Λ-class reactions:

In Fig. 1 we show the results for $d\sigma/dt$ and the polarization for reaction (1) when the resonance parameters given in Table I are used. These parameters are also used to plot $d\sigma/dt$ for reaction (2) shown in Fig. 2. Figure 3 shows our predictions for $d\sigma/dt$ and the polarization for process (3). The resonance parameters needed for this plot are given in Table II.

Our agreement with experiments for $d\sigma/dt$, in general, is reasonable for reactions (1) and (3). The agreement is poor for reaction (2) and for reaction (3) at momenta below 1.70 GeV/c. Due to the uncertainty and paucity of data it is very difficult to draw any definite conclusion regarding the prediction of polarization for reaction (1).

(B) Σ-class reactions:

Figure 4 shows the angular-distribution plot for reaction (4) when the resonance parameters given in Table III are used. Figure 5 shows the similar plot for reaction (5) with only the Σ resonance parameters given in Table III. The resonance parameters for reactions (6) and (7) are given in Table IV. Figure 6 shows $d\sigma/dt$ for reaction (6) and Fig. 7 shows $d\sigma/dt$ and the polarization for reaction (7).

The angular-distribution data are reproduced reasonably well for reactions (4), (5), and (7). The agreement is poor for reaction (6) at momenta below 3 GeV/c. The polarization data for reaction (7) are not reproduced by our model. Above 4.0 GeV/c we predict almost zero polarization where experiments show considerable values.

The fit between our model and the data could possibly be improved when more data for resonances at higher energies become available. In particular our failure to predict a reasonable amount of polarization for the reaction $\pi^+p \to K^+\Sigma^+$ at higher energies is due to the fact that our list of Δ resonances stops at a small center-of-mass energy.

We find that the new interference model is capable of explaining a vast body of data for the

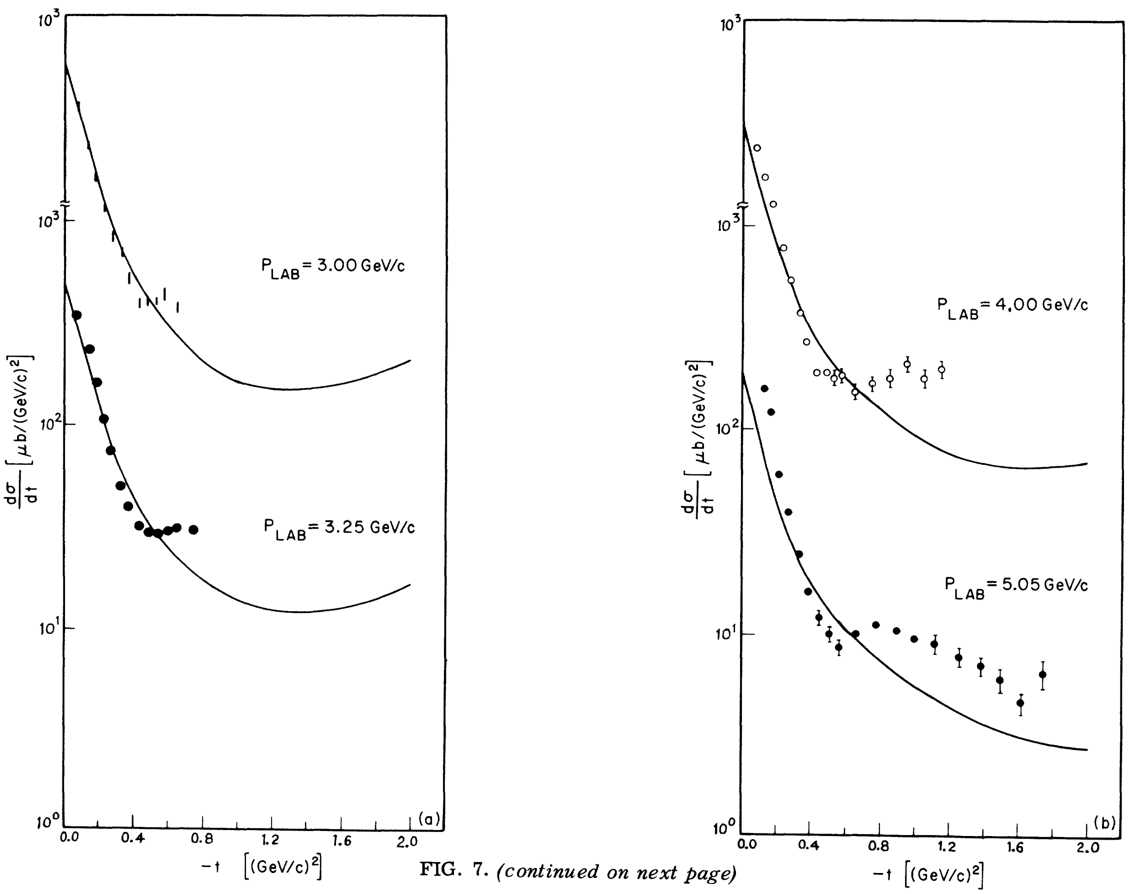
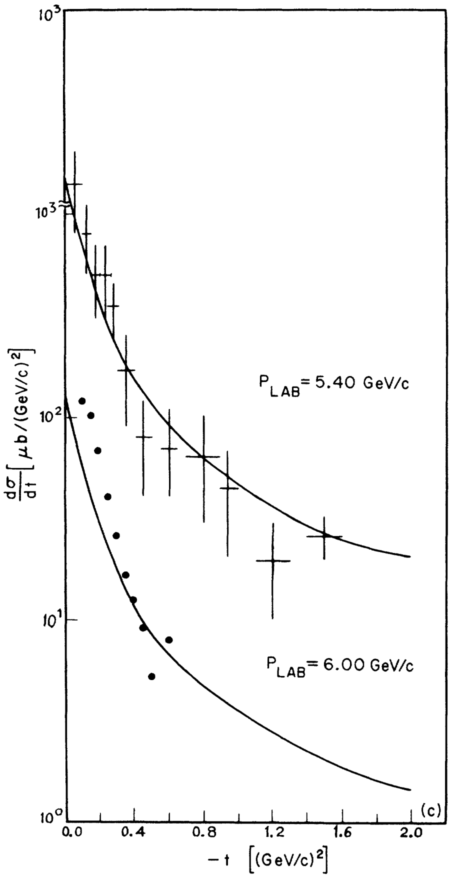


FIG. 7. *(continued on next page)*



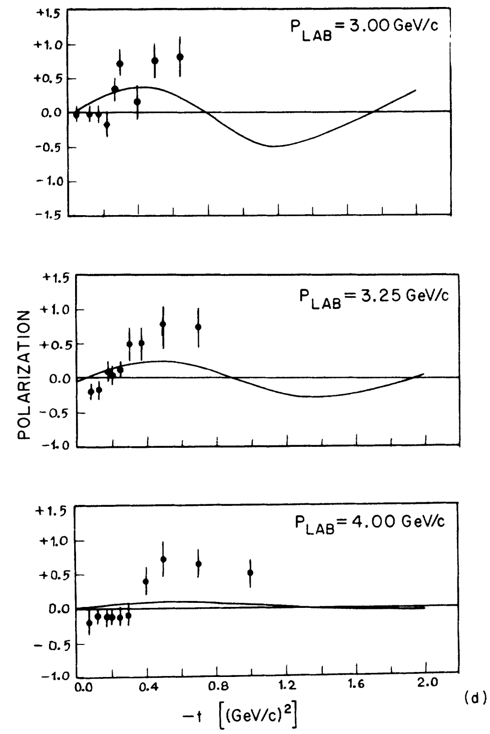


FIG. 7. The production angular distribution for the process $\pi^+ p \to K^+ \Sigma^+$ at the incident pion momenta of (a) 3.00 and 3.25 GeV/c; (b) 4.00 and 5.05 GeV/c; (c) 5.40 and 6.00 GeV/c; the polarization for the same reaction at incident pion momenta of (d) 3.00, 3.25, and 4.00 GeV/c. The experimental data have been taken from Pruss *et al.* (Ref. 17) for momenta of 3.00, 3.25, 4.00, and 5.05 GeV/c, from Cooper *et al.* (Ref. 18) for 5.40 GeV/c, and from Bashian *et al.* (Ref. 19) for 6.00 GeV/c.

hypercharge-exchange meson-baryon reactions. The predictions of this model can be favorably compared with those of others.[1-3]

ACKNOWLEDGMENTS

R. K. is grateful to the Council of Scientific and Industrial Research, New Delhi, for financial assistance. Help given by Shri Vijai Kumar Agarwal and Shri Pankaj Sharan at I.I.T. Kanpur in computer programming is also gratefully acknowledged.

TABLE IV. The decay widths and elasticities of resonances.[a]

Resonance	J^P	Γ_{used} (GeV)	Γ_{exp} (GeV)	$100\times(\Gamma_1\Gamma_2)^{1/2}_{\text{used}}$ (GeV)	$100\times(\Gamma_1\Gamma_2)^{1/2}_{\text{exp}}$ (GeV)	ϕ
$\Delta(1670)$	$\frac{3}{2}^-$	0.175	0.175–0.300	0.03	~0.03–0.05	–
$\Delta(1690)$	$\frac{3}{2}^+$	0.600	0.240–0.600	0.08	~0.03–0.08	–
$\Delta(1890)$	$\frac{5}{2}^+$	0.350	0.135–0.350	1.29	~0.50–1.29	–
$\Delta(1910)$	$\frac{1}{2}^+$	0.420	0.230–0.420	2.40	~1.03–1.90	–
$\Delta(1950)$	$\frac{7}{2}^+$	0.220	0.140–0.220	2.09	~1.33–2.09	–
$\Delta(1960)$	$\frac{5}{2}^-$	0.400	0.200–0.400	1.55	0.77–1.55	–
$\Delta(2420)$	$\frac{11}{2}^+$	0.350	0.270–0.350	0.82	...	–

[a] The experimental values have been quoted from the table of the Particle Data Group (Ref. 9).

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Possible Origin for Symmetry Breaking*

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We conjecture that the total Lagrangian of strong, electromagnetic, and weak interactions is invariant under the "left-handed SU(2)" of the weak currents, which is however spontaneously broken. We discuss a formula for the "tadpole" part of the K-meson electromagnetic mass splitting, which may be related to the present scheme.

Several authors[1-4] pointed out that it is possible to construct unified theories of the weak and electromagnetic interaction based on the left-handed SU(2) group generated by the leptonic and Cabibbo weak currents. The theory may be arranged so that the Lagrangian is exactly invariant under this SU(2) group. This symmetry is then *spontaneously* broken[2,3] so that the multiplets of particles involved no longer are degenerate in mass. Specifically, the e mass splits away from the ν_e mass (which is zero), the μ mass splits away from the ν_μ mass and the intermediate-boson mass splits away from the photon mass. Because of the presence of gauge fields, no Goldstone bosons appear.[5] It is clear that not all of these splittings are small. Thus, it is tempting to speculate that this mechanism may in fact be responsible for the apparent symmetry breaking of the strong Lagrangian which we take to be *exactly chiral-SU(3)* $\times$ *SU(3)-invariant*.

Since the left-handed SU(2) group of the Cabibbo currents is a subgroup of chiral SU(3) $\times$ SU(3) we would then have the situation where $\mathcal{L}_{\text{strong}} + \mathcal{L}_{\text{electromagnetic}} + \mathcal{L}_{\text{weak}}$ is invariant under this SU(2) group. This is our basic conjecture.

First we list the fields needed to construct all presently known particles (neglecting gravity):

(i) the leptons e, ν_e, μ, and ν_μ;

(ii) the photon and possibly some intermediate vector bosons;

(iii) the quarks q_1, q_2, and q_3.

We next give the transformation properties[3] of the fields with respect to the left-handed SU(2). For convenience we define new quark fields related