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Y^*'s WITH SPIN 7/2

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Several years ago, Cook et al. measured the total K^-p cross section from 1 to 4 BeV/c K^- lab momentum and observed a broad low bump centered at about 1.6 BeV/c (total c.m. energy 2065 MeV).[1] Blanpied et al.,[2] Böck et al.,[3] and Eberhard and Shively[4] have observed bumps in invariant-mass distributions which may indicate existence of Y^*'s with masses above 1900 MeV, but statistical accuracy of and (or) agreement among the experiments is poor. Recently, Cool et al. measured very accurately total K^-p and K^-d cross sections from 1.0 to 2.45 BeV/c (1794 to 2411 MeV) and found evidence for a number of Y^*'s.[5] Among them are an isotopic spin $I=1$ $Y^*(\sim 2030)$, which we have previously reported,[6] and an $I=0$ $Y^*(\sim 2100)$, for which we here give independent evidence. In addition, we determine the $Y_1^*(2030)$ to have spin-parity $J^P = 7/2^+$ and the $Y_0^*(\sim 2100)$ to have $J^P = 7/2^-$.

The 72-in. hydrogen bubble chamber was exposed at the Bevatron to a K^- beam with momenta 1.22, 1.42, 1.51, 1.60, and 1.70 BeV/c. We found about 30 000 events consisting of a disappearing beam track and an associated V-like charged decay of a neutral particle. After kinematic analysis and imposition of other selection criteria, 8408 $\bar{K}^0$ events ($K_1^0 \to \pi^+ + \pi^-$) and 14 173 Λ events ($\Lambda \to p + \pi^-$) remained. About half the former are $K^- + p \to \bar{K}^0 + n$ (charge-exchange) events; about half the latter are $K^- + p \to \Lambda + \pi^0$ events. Cross sections and

production and (for the $\Lambda\pi^0$ events) polarization angular distributions were measured. Table I gives the cross sections. Experimental details and a more complete discussion of results than can be given here will appear in an article.

The scattering amplitudes for the two reactions in terms of pure I-spin amplitudes are

$$A(K^- + p \rightarrow \bar{K}^0 + n) = (A^1_{\bar{K}N} - A^0_{\bar{K}N})/2 \tag{1a}$$

$$A(K^- + p \rightarrow \Lambda + \pi^0) = (A^1_{\Lambda\pi})/\sqrt{2}\,, \tag{1b}$$

where superscripts give I-spin. Differential cross sections were expanded in a Legendre polynomial series

$$\frac{d\sigma}{d\Omega} = c\lambda^2 \sum_{n=0}^{n_{max}} a_n P_n(\cos\theta), \tag{2}$$

where λ is $\hbar/q$ (q is the K^- c.m. momentum), θ is the c.m. scattering angle between mesons, and c is the square of the numerical factor in Eqs. (1): 1/4 for $K^- + p \rightarrow \bar{K}^0 + n$, 1/2 for $K^- + p \rightarrow \Lambda + \pi^0$. The equation $\sigma = 4\pi c\lambda^2 a_0$ relates σ and a_0. Figures 1 and 2 show the coefficients a_n for the two reactions from this and other experiments.[7,8]

Coefficients a_n are related to partial-wave amplitudes. Labeling specific partial-wave amplitudes L_{2J} (where L is orbital angular momentum), i.e., S_1, P_1, P_3, D_3, etc., and terms in this series T_i, with i = 1, 2, 3, 4, etc., we can expand the a_n:

$$a_n = \sum_{i \leq j} \alpha_n^{ij} \mathrm{Re}(T_i^* T_j) = \sum_{i \leq j} \alpha_n^{ij} \underset{\sim}{T}_i \cdot \underset{\sim}{T}_j. \tag{3}$$

The amplitudes have been treated as complex numbers and as two-component vectors in turn. Table II gives an abbreviated set of the α_n^{ij}.

All nonzero a_n^{ij} are positive. The interference between amplitudes having angular momenta J_1 and J_2 and even (odd) relative parity contributes to the a_n with n even (odd) and $|J_1-J_2| \leq n \leq (J_1+J_2)$.

$K^- + p \rightarrow \bar{K}^0 + n$

Around 1 BeV/c the coefficients are dominated by the D_5 $Y_1^*(1760)$ and the F_5 $Y_0^*(1820)$.[9] Effects are large because both resonances couple strongly to the $\bar{K}N$ channel. Between 1.2 and 2.0 BeV/c, a_6 and a_7 are large and variable, whereas above 2.2 BeV/c there is little requirement for either $P_6(\cos\theta)$ or $P_7(\cos\theta)$. Around 2.5 BeV/c all coefficients are positive, so all polynomials add constructively to a peak in the forward direction. The peak narrows with increasing momentum -- from 2.24 to 2.70 BeV/c low coefficients decrease, whereas high coefficients increase. We can attribute the peak to a peripheral mechanism. The peaking persists down to about 1.5 BeV/c, but below 2 BeV/c it is quite broad and the requirement there for $P_6(\cos\theta)$ and $P_7(\cos\theta)$ is due rather to undulations in the angular distribution than to the peak. Therefore we must attribute the behavior of a_6 and a_7 between 1.2 and 2.0 BeV/c to something other than a peripheral mechanism. A peripheral mechanism very probably does not necessitate higher terms in the Legendre polynomial series below 2 BeV/c than it does above 2 BeV/c. The coefficients above 2 BeV/c indicate that below 2 BeV/c the projections of the peripheral-mechanism amplitude on partial-wave amplitudes with $J > 5/2$ are negligible.

Since coefficients higher than a_7 are consistent with zero, we assume amplitudes with $J > 7/2$ may be neglected.[8] The coefficients

a_6 and a_7 provide refined information about the $J = 7/2$ amplitudes. At least one $J = 7/2$ amplitude is present at 1.22 BeV/c, since a_6 is nonzero there (see Table II). Above 1.4 BeV/c, a_7 indicates that $J = 7/2$ amplitudes in both parity states are present. The magnitude of a_7 sets a lower limit on the magnitudes of these amplitudes. The simple inequalities

$$(|\underset{\sim}{F}_7|^2 + |\underset{\sim}{G}_7|^2) \geq 2\,|\underset{\sim}{F}_7| \cdot |\underset{\sim}{G}_7| \geq 2\,|\underset{\sim}{F}_7 \cdot \underset{\sim}{G}_7| \tag{4}$$

and coefficients of Table II yield:

$$|\underset{\sim}{F}_7| \cdot |\underset{\sim}{G}_7| \geq (429/9800)\,|a_7| = 0.044\,|a_7| \tag{5}$$

$$a_0 \text{ from } J = 7/2 \text{ amplitudes} \geq 8 \times 0.044\,|a_7| = 0.35\,|a_7|. \tag{6}$$

From 1.6 to 1.8 BeV/c, $|a_7|$ approximately equals a_0, so $J = 7/2$ amplitudes account for at least a third of the cross section.

The squares of $J = 7/2$ amplitudes contribute to a_6. These contributions are always positive and appear also in a_0, enlarged by a factor $4 \times 33/100 = 1.32$. Experimentally, at 1.22 and 1.42 BeV/c a_6 is too large to be consistent with a_0 if the only contributions to a_6 are from $J = 7/2$ amplitudes. Above 1.7 BeV/c, a_6 is negative. The only other terms contributing to a_6 are the F_5F_7 and D_5G_7 interferences. One or both must be important from 1.2 to 2.0 BeV/c.

To summarize, the $J = 7/2$ amplitudes are large, vary considerably with energy, and cannot be associated with a peripheral mechanism. We now investigate the possibility they are resonant amplitudes.

The amplitude for resonant scattering from channel α to channel β is

$$T_{\alpha\beta}(\omega) = \frac{(x_\alpha x_\beta)^{1/2}}{\epsilon - i}, \tag{7}$$

where $x_\alpha = \Gamma_\alpha/\Gamma$, and $\epsilon \approx (\omega_0 - \omega)/(\Gamma/2)$. Here ω_0 is the resonant energy and ω is the total c.m. energy. For elastic or charge-exchange scattering $x_\alpha = x_\beta = x$ and $T = x/(\epsilon - i)$. Figure 3a shows that the amplitude traces a circle of diameter x in the counter-clockwise direction as energy increases. The interference between two resonant amplitudes is given by

$$\underset{\sim}{T}_i \cdot \underset{\sim}{T}_j = \frac{x_i x_j (1 + \epsilon_i \epsilon_j)}{(1 + \epsilon_i^2)(1 + \epsilon_j^2)} = x_i x_j I, \tag{8}$$

where $I = I(\epsilon_i, \epsilon_j)$ contains the energy dependence of the interference. Figure 3 shows patterns for three cases. (For simplicity we have assumed the widths of the resonances are equal; effects of unequal widths and variation of widths with energy do not change the qualitative characteristics.) The factor I must be multiplied by the product of coupling constants $x_i x_j$ and by the appropriate expansion coefficient a_n^{ij} to obtain the contribution of the interference to an a_n. If the resonances are in different I-spin states that are coupled by a minus sign, the patterns are reflected across the $I(\epsilon_i, \epsilon_j) = 0$ axis. The interference between two widely separated resonances [Fig. 3d] is dominated by the real parts of the resonant amplitudes, since at any energy at least one of the amplitudes is predominantly real; the resonances are close to the nodes, near which one of the amplitudes is purely imaginary and its real part changes sign.

The pattern of a_7 (Fig. 1) resembles that of Fig. 3b reflected across the $I(\epsilon_i, \epsilon_j) = 0$ axis. The simplest conclusion is that there are two overlapping resonances with different values of I-spin. Equation (5) puts a lower limit of $(0.18)^2$ on the product of the elasticities $x_i x_j$.

The pattern of a_6, centered at about 1.3 BeV/c, resembles that of Fig. 3d reflected across the $I(\epsilon_i, \epsilon_j) = 0$ axis. One node is near 1 BeV/c--near $J = 5/2$ resonances. The other node is near the maximum of $|a_7|$, where we suppose there are $J = 7/2$ resonances. We showed above that interference between $J = 5/2$ and $7/2$ amplitudes dominates a_6. If a_6 is due largely to interferences between $J = 7/2$ resonances and the known $J = 5/2$ resonances, then to contribute to a_6 with the proper sign, the $F_7 Y^*$ must have I-spin different from the $F_5 Y_0^*$ and the $G_7 Y^*$ must have I-spin different from the $D_5 Y_1^*$. Thus a_6 as well as a_7 puts $J = 7/2$ resonances in different I-spin states; in addition, it specifies which I-spin state is associated with which parity state.

$K^- + p \rightarrow \Lambda + \pi^0$

This pure $I = 1$ channel provides independent evidence for the existence of an $F_7 Y_1^*$. Existence of a resonance is shown by a peak in a_0 at about 2030 MeV. Spin 7/2 is indicated by the requirement for $P_6(\cos\theta)$ and the structure of its coefficient a_6. The parity determination is based on the following experimental facts. (a) In the forward direction (peripheral region), there is destructive interference between resonance and background below resonance and constructive interference above resonance (a_3, a_4, and a_5 change from negative to positive around 2030 MeV). (b) In the same (peripheral) region, the Λ polarization is negative from below to above the resonance and reaches 100% near 2030 MeV. It can be shown that an $F_7 Y_1^*$ interfering with a predominantly real peripheral background reproduces these facts; a $G_7 Y_1^*$ interfering with the same background would have opposite polarization.

Above 1.5 BeV/c the forward peak in the $\Lambda\pi^0$ differential cross sections is much sharper than in corresponding charge-exchange distributions, and few data exist between 2 and 3 BeV/c to set probable upper limits of peripheral-mechanism effects on high partial-wave amplitudes. Thus the dominance of high partial waves by resonant amplitudes is not as clear as in the charge-exchange case. Yet the predictions of such dominance are qualitatively correct. The D_5 $Y_1^*(1760)$ and F_7 $Y_1^*(2030)$ alone require that a_7 be zero and a_6 be just $|F_7|^2$. Experimentally, a_7 is much smaller than other coefficients, and a_6 roughly reproduces the peak in a_0.

We cannot accurately determine either branching fractions or widths while the magnitude and shape of backgrounds in a_0 are unknown. For instance, if all the $K^- + p \rightarrow \Lambda + \pi^0$ a_6 is attributed to $|F_7|^2$, 5/6 of σ is due to the resonance; this seems too much. Curves in Fig. 2 are drawn for the case $(x_{\bar{K}N} x_{\pi\Lambda})^{1/2} = 0.20$ and $\Gamma = 170$ MeV. Using this width for the $Y_1^*(2030)$, $\Gamma = 100$ MeV and $x = 0.5$ for the $Y_1^*(1760)$, and $\Gamma = 50$ MeV and $x = 0.7$ for the $Y_0^*(1820)$, we fit the charge-exchange a_6 and a_7.[10] Parameters of Table III lead to the curves in Fig. 1. Better fits can be obtained, but then the $Y_1^*(2030)$ elasticity is too high to be compatible with a_0. There is considerable discrepancy in a_6 between data and curves from 1.2 to 1.5 BeV/c. Cool et al. report an $I = 1$ $Y^*(\sim 1900)$ with Γ uncertain and $x \simeq 0.1$.[5] If this has $J^P = 5/2^+$, it contributes to a_6 by interfering with the $Y_1^*(2030)$. Then if the $Y_1^*(1900)$ width is larger than about 100 MeV, the relevant interference pattern is something between Fig. 3b and c, and the interference adds to a_6 with the proper sign to reduce the discrepancy between data and curves in Fig. 1.

The $Y_1^*(2030)$ and $Y_0^*(\sim 2100)$ have necessary properties to be interpreted as first recurrences of the $Y_1^*(1385)$ and $Y_0^*(1520)$. Since the $Y_1^*(1385)$ is a member of the SU(3) decuplet that contains the $N_{3/2}^*(1238)$, the $Y_1^*(2030)$ is a member of the decuplet that contains the recurrence of the $N_{3/2}^*(1238)$, the $N_{3/2}^*(1920)$. By the equal-mass-spacing rule there should be a $\Xi_{1/2}^*(\sim 2140)$ and an $\Omega^*(\sim 2250)$. In exact SU(3) the process decuplet $\rightarrow$ octet + octet is characterized by a single coupling constant, and the rates $\Gamma_{\pi N}$, $\Gamma_{\bar{K}N}$, and $\Gamma_{\pi\Lambda}$ for the decays $N_{3/2}^* \rightarrow \pi + N$, etc., should be in the ratio 6:2:3. Because masses within a multiplet are not equal, the rates need correcting. The corrections should be small because the final-state c.m. momenta for the three decays (723, 702, and 700 MeV/c) are almost equal (see footnote 10). For the $N_{3/2}^*(1920)$, Γ is about 170 MeV, and x is about 0.6.[11] We obtain $\Gamma_{\pi N}: \Gamma_{\bar{K}N}: \Gamma_{\pi\Lambda} \simeq x_{\pi N}: x_{\bar{K}N}: x_{\pi\Lambda} \simeq 0.6: 0.25: 0.16$. A reduction of $x_{\bar{K}N}$ and consequent increase of $x_{\pi\Lambda}$ could make agreement between theory and experiment very good.

Since it is not clear whether the $Y_0^*(1520)$ is a singlet or a member of the octet that contains the $N_{1/2}^*(1518)$, it is not clear whether the $Y_0^*(\sim 2100)$ is associated with the G_7 $N_{1/2}^*(2190)$.[11,12]

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FOOTNOTES AND REFERENCES

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1. V. Cook, B. Cork, T. F. Hoang, D. Keefe, L. T. Kerth, W. A. Wenzel, and T. F. Zipf, Phys. Rev. 123, 320 (1961).

2. W. A. Blanpied, J. S. Greenberg, V. W. Hughes, P. Kitching, D. C. Lu, and R. C. Minehart, Phys. Rev. Letters 14, 741 (1965).

3. R. K. Böck, W. A. Cooper, B. R. French, J. B. Kinson, R. Levi-Setti, D. Revel, B. Tallini, and S. Zylberajch, Physics Letters 17, 166 (1965).

4. Philippe Eberhard, Bull. Am. Phys. Soc. 10, 478 (1965). Frank T. Shively (Lawrence Radiation Laboratory), private communication.

5. R. L. Cool, G. Giacomelli, T. F. Kycia, B. A. Leontic, K. K. Li, A. Lundby, and J. Teiger, Bull. Am. Phys. Soc. 11, 326 (1966).

6. C. G. Wohl, F. T. Solmitz, and M. L. Stevenson, Bull. Am. Phys. Soc. 10, 529 (1965). Charles Gordon Wohl (Ph.D. Thesis), Lawrence Radiation Laboratory Report UCRL-16288, July 1965. M. Lynn Stevenson, Bull. Am. Phys. Soc. 10, 1179 (1965).

7. (a) P. L. Bastien and J. P. Berge, Phys. Rev. Letters 10, 188 (1963), (b) G. B. Yodh, K^-p Interactions at 940 MeV/c and Their Bearing on Y^*(1765), U. of Maryland Dept. of Physics Report No. 456, May 1965. (c) C. G. Wohl and S. G. Wojcicki (Lawrence Radiation Laboratory), unpublished data. (d) W. Graziano and S. G. Wojcicki, Phys. Rev. 128, 1868 (1962).

(e) W. P. Trower (U. of Illinois), private communication, 1966. (f) B. Buschbeck-Czapp, I. Wacek, W. A. Cooper, A. Fridman, E. Malamud, G. Otter, E. Gelsema, and A. Tenner, in Proceedings of the Sienna International Conference on Elementary Particles (Societa Italiana di Fisica, Bologna, 1963), p. 166. (g) P. M. Dauber, Phys. Rev. 134, B1370 (1964); P. M. Dauber and H. K. Ticho (UCLA), private communication, 1965. (h) D. Barge, W. Chu, L. Leipuner, R. Crittenden, H. J. Martin, F. Ayer, L. Marshall, A. C. Li, W. Kernan, and M. L. Stevenson, Phys. Rev. Letters 13, 69 (1964). (i) G. W. London, R. R. Rau, N. P. Samios, S. S. Yamamoto, M. Goldberg, S. Lichtman, M. Primer, and J. Leitner, Phys. Rev. 143, 1034 (1966). (j) A. Barbaro-Galtieri and R. D. Tripp, Lawrence Radiation Laboratory Report UCRL-11429, July 1964.

8. Dauber [Ref. 7 (g)] reports nonzero a_9 and a_{10} at 1.80 BeV/c. A least-squares refit gives a 10% confidence level for $n_{max} = 7$.

9. O. Chamberlain, K. M. Crowe, D. Keefe, L. T. Kerth, A. Lemonick, T. Maung, and T. F. Zipf, Phys. Rev. 125, 1696 (1962). L. Sodickson, I. Mannelli, D. Frisch, and M. Wahlig, Phys. Rev. 133, B757 (1964). William R. Holley (Ph.D. Thesis), Lawrence Radiation Laboratory Report UCRL-16274, October 1965. R. W. Birge, R. P. Ely, G. E. Kalmus, A. Kernan, J. Louie, J. S. Sahouria, and W. M. Smart, Lawrence Radiation Laboratory Report UCRL-16252, June 1965. A. Barbaro-Galtieri, A. Hussain, and R. D. Tripp, Phys. Letters 6, 296 (1963). R. Armenteros, M. Ferro-Luzzi, D. W. G. Leith, R. Levi-Setti, A. Minten, R. D. Tripp, H. Filthuth, V. Hepp, E. Kluge, H. Schneider, R. Barloutaud, P. Granet, J. Meyer, and

J.-P. Porte, Phys. Letters 19, 338 (1965). R. B. Bell, R. W. Birge, Y.-L. Pan, and R. T. Pu, Phys. Rev. Letters 16, 203 (1966).

10. Widths have been given the energy dependence

$$\Gamma \propto \frac{q'}{\omega}\left(\frac{q'^2}{q'^2 + M^2}\right)^L ,$$

where q' is the final-state c.m. momentum and M is a mass characterizing the radius of interaction. We use M = 350 MeV.

11. A. H. Rosenfeld, A. Barbaro-Galtieri, W. H. Barkas, P. L. Bastien, J. Kirz, and M. Roos, Rev. Mod. Phys. 37, 633 (1965).

12. A. Yokosawa, S. Suwa, R. E. Hill, R. J. Esterling, and N. E. Booth, Phys. Rev. Letters 16, 714 (1966).

Table I. Cross sections for the reactions $K^- + p \rightarrow \overline{K}^0 + n$ and $K^- + p \rightarrow \Lambda + \pi^0$. Quoted errors are statistical only; $\Lambda\pi^0$ cross sections may be systematically 5-10% high because of $\Lambda - \Sigma^0$ separation problems.

K^- lab momentum (BeV/c)	Total c.m. energy (BeV)	$\sigma(K^- + p \rightarrow \overline{K}^0 + n)$ (mb)	$\sigma(K^- + p \rightarrow \Lambda + \pi^0)$ (mb)
1.22	1.896	2.83 ± 0.14	1.58 ± 0.07
1.42	1.986	1.90 ± 0.12	1.37 ± 0.07
1.51	2.026	1.83 ± 0.09	1.37 ± 0.06
1.60	2.065	1.93 ± 0.13	1.10 ± 0.07
1.70	2.109	1.66 ± 0.10	0.94 ± 0.05

Table II. Abbreviated table of partial-wave expansion coefficients a_n^{ij}. All contributions to a_0, a_6, and a_7 from amplitudes with $J \leq 7/2$ are included.

$T_i T_j$ [a]	a_0	a_6	a_7
$S_1S_1 + P_1P_1$	1		
$P_3P_3 + D_3D_3$	2		
$D_5D_5 + F_5F_5$	3		
$F_7F_7 + G_7G_7$	4	100/33	
F_7G_7			9800/429
$F_5F_7 + D_5G_7$		200/11	

[a] With the a_n normalized as in Eq. (2), read the T_i as $(T_i^1 - T_i^0)_{\bar{K}N}$ for $K^- + p \rightarrow \bar{K}^0 + n$, and as $(T_i^1)_{\Lambda\pi}$ for $K^- + p + \Lambda + \pi^0$.

Table III. Properties of the J = 7/2 resonances.

I, J^P	ω_0 (MeV)	Γ (MeV)	$x_{\bar{K}N}$	$x_{\Lambda\pi}$
$1, 7/2^+$	2030	170	0.25	0.16
$0, 7/2^-$	2120	145	0.25	-

FIGURE LEGENDS

Fig. 1. Coefficients a_n for the reaction $K^- + p \rightarrow \overline{K}^0 + n$. Curves are effects of the $Y_1^*(1760)$, $Y_0^*(1820)$, $Y_1^*(2030)$, and $Y_0^*(2120)$.

Fig. 2. Coefficients a_n for the reaction $K^- + p \rightarrow \Lambda + \pi^0$. Curves are effects of the $Y_1^*(2030)$.

Fig. 3. (a) A Breit-Wigner resonant amplitude. (b-d) Patterns of interference between two resonant amplitudes at various separations.

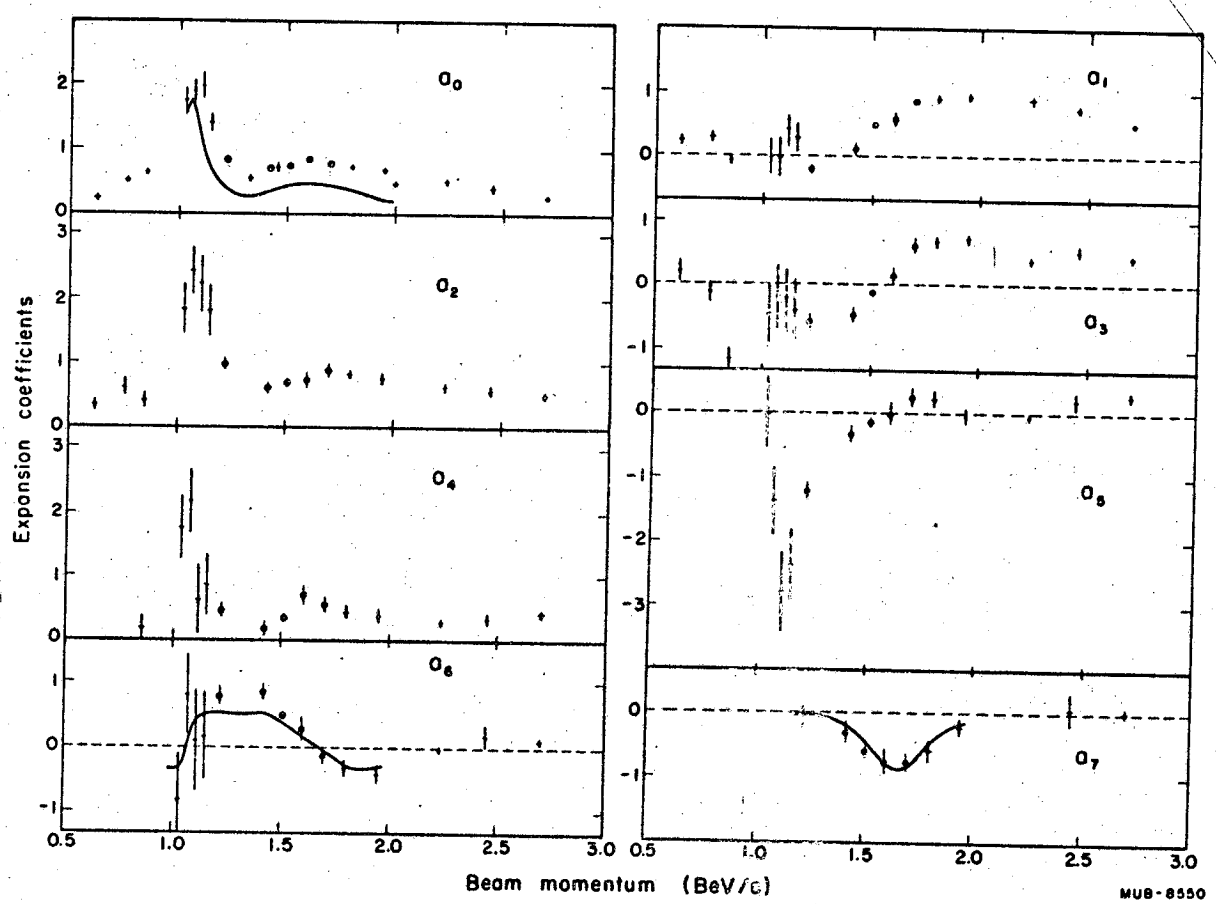
Expansion coefficients
a_0
a_1
a_2
a_3
a_4
a_5
a_6
a_7
Beam momentum (BeV/c)
MUB-8550

Fig. 1

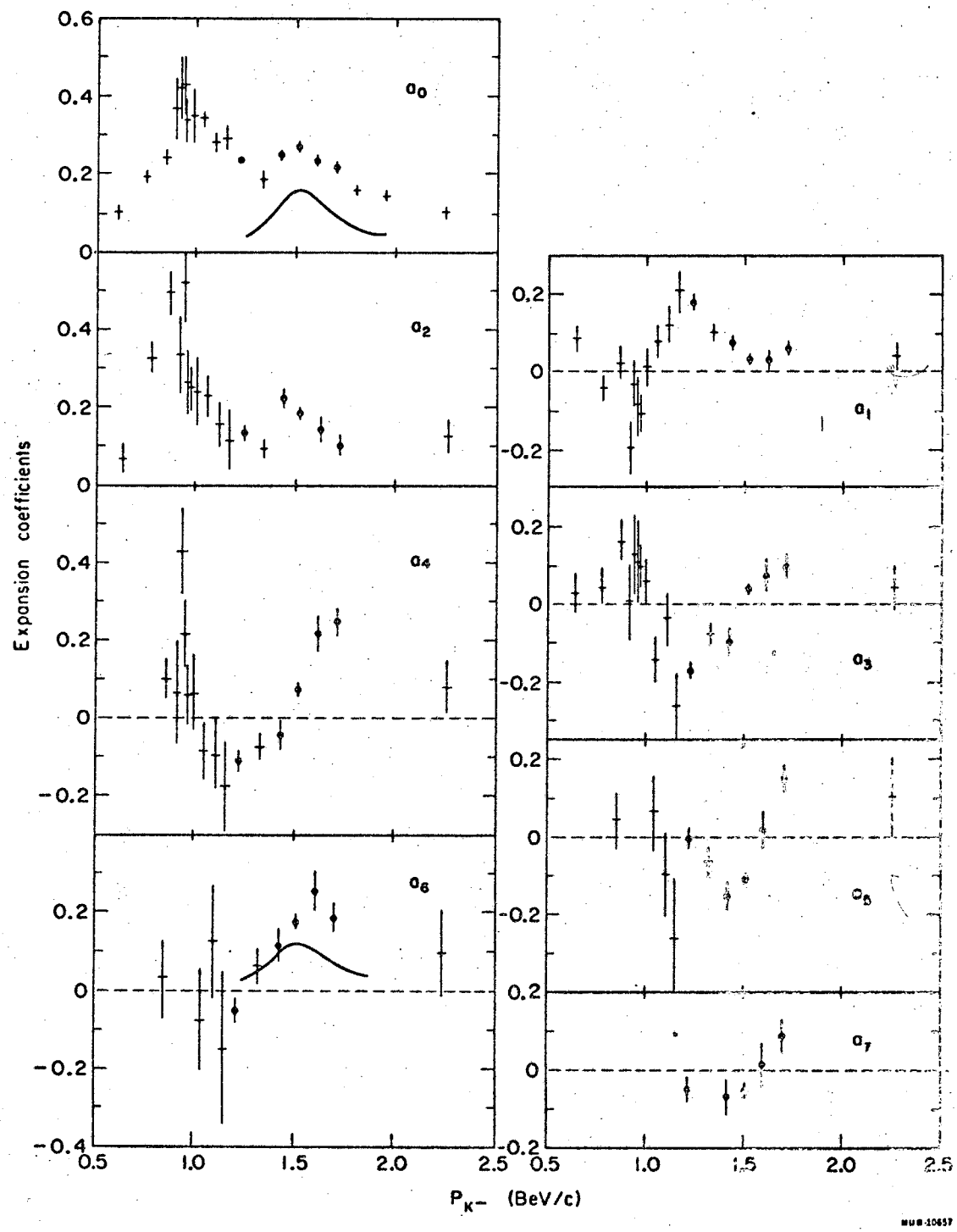
Expansion coefficients
a_0
a_1
a_2
a_3
a_4
a_5
a_6
a_7
P_{K^-} (BeV/c)
MUB-10657

Fig. 2

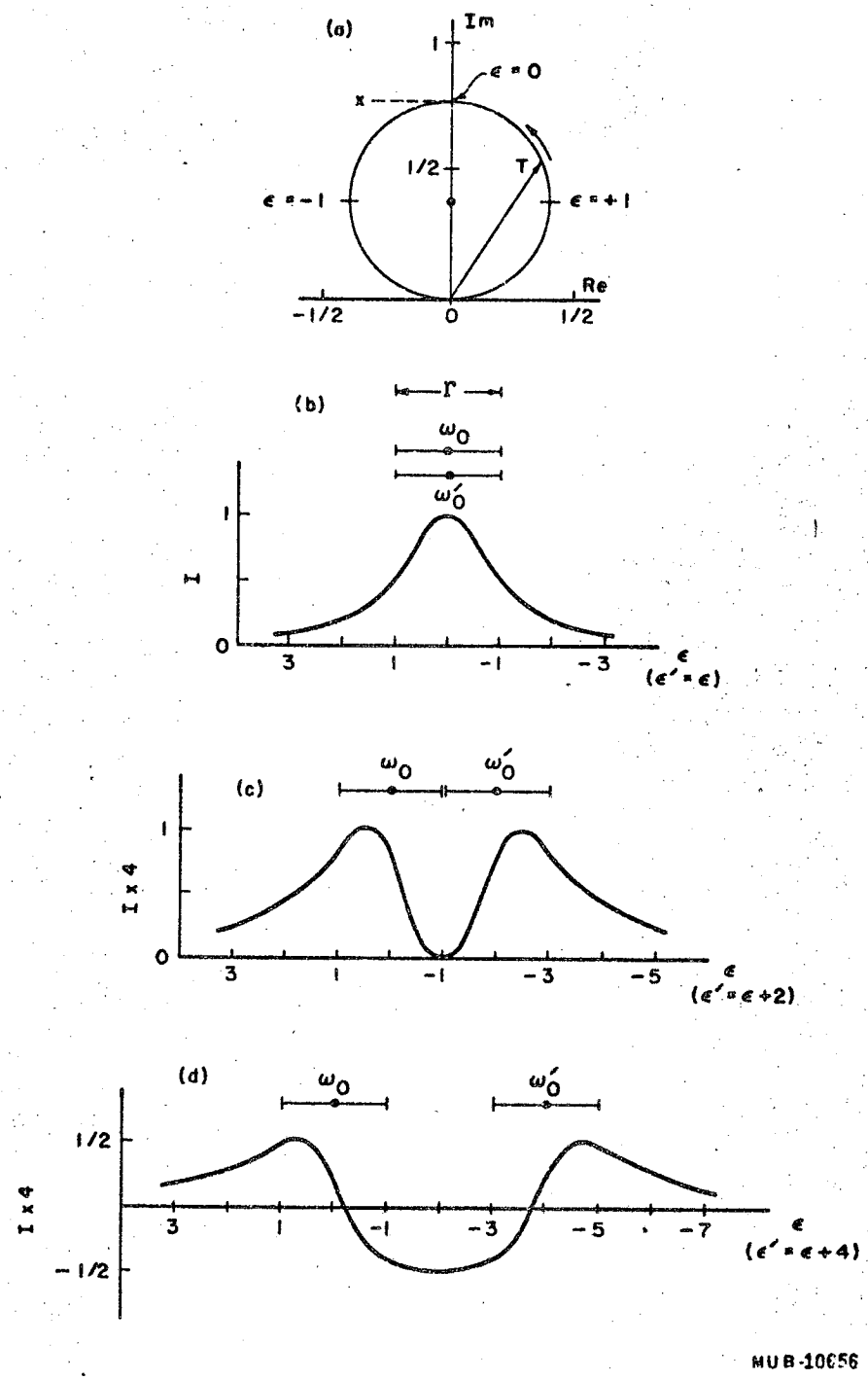
(a)
Im
1
ε = 0
x
1/2
T
ε = -1
ε = +1
Re
-1/2
0
1/2
(b)
Γ
ω0
ω'0
1
I
0
3
1
-1
-3
ε
(ε' = ε)
(c)
ω0
ω'0
1
I x 4
0
3
1
-1
-3
-5
ε
(ε' = ε+2)
(d)
ω0
ω'0
1/2
I x 4
-1/2
3
1
-1
-3
-5
-7
ε
(ε' = ε+4)
MUB-10656

Fig. 3

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