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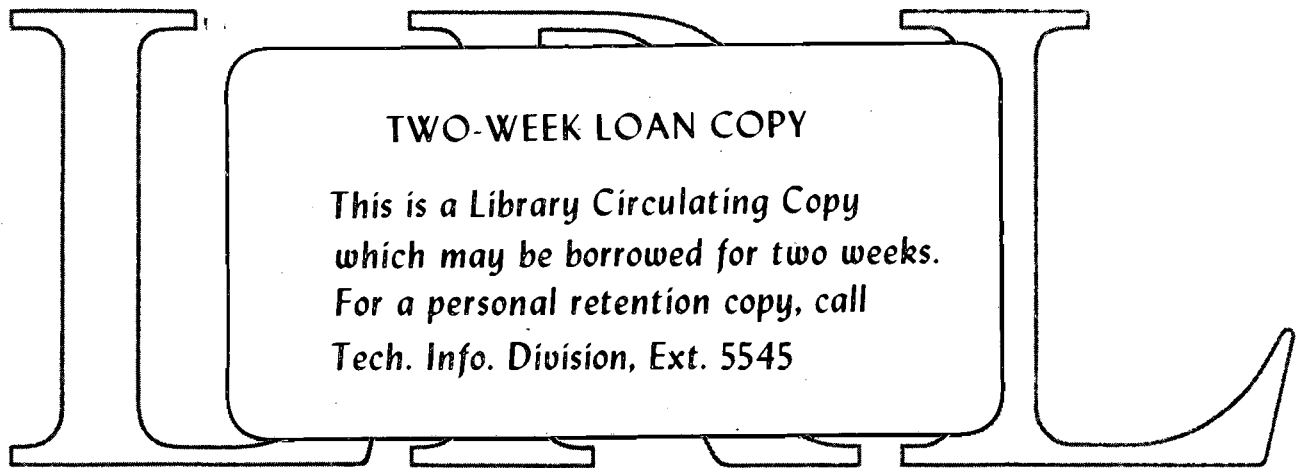
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$K^+p$  ELASTIC SCATTERING AT 864, 969, AND 1207 MeV/c\*

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May 16, 1969

The differential cross section for  $K^+p$  elastic scattering has been measured at 864, 969, and 1207 MeV/c. Our data show a smooth transition from low-energy s-wave scattering to high-energy diffraction, and are somewhat in disagreement with a recent experiment on  $K^+p$  backward scattering.

The general features of  $K^+p$  elastic scattering have been known for some time:<sup>1-7</sup> below 800 MeV/c a single wave, the S wave, appears to dominate, and above 1400 MeV/c a completely diffractive behavior is encountered. Of particular interest is the 800-1400-MeV/c transition region, which spans the onset of inelastic processes and contains the only large structure in the  $K^+p$  total cross section. In this paper we present differential cross sections for  $K^+p$  elastic scattering at 864, 969, and 1207 MeV/c. We see a smooth transition from the low-energy isotropy to the high-energy diffraction, with minimal structure in the Legendre coefficients in the transition region. We also find our data in the backward direction to be completely inconsistent with the recent counter measurements by Carroll et al.<sup>8</sup>

Our data come from an exposure of the LRL 25-inch hydrogen bubble chamber to a mass-separated  $K^+$  beam at the Bevatron. Most of the events were measured on the Berkeley Flying-Spot Digitizer. We analyzed all events occurring within our fiducial volume, yielding 10500, 5600, and

6300  $K^+p$  elastic scatterings at 864, 969, and 1207 MeV/c, respectively. Since all events were measured, the data could be normalized to the accurate total cross section measurements of Cool et al.<sup>9</sup> and Bugg et al.;<sup>10</sup> the resulting error in normalization was  $\pm 2$  to 3%. Complete details of the analysis and normalization procedure will appear in a later paper.<sup>11</sup>

The major biases in our event sample arise from three sources of scanning loss: (1) loss of forward events, for which the  $K^+$  deflection becomes small and the recoil-proton track short; (2) loss of backward-scattering events, which are nearly collinear with the incident  $K^+$ ; (3) loss of events for which the plane of the scattering is perpendicular to the camera plane, and hence for which there is little apparent deflection of the secondaries. To minimize these biases we took the following steps: (a) about 20% of the film at each momentum was rescanned, and corrections were made based on the newly found events (numbering about 3.5% of the first-scan events); (b) we removed all events with  $\phi$  between 60 and 120 deg, where  $\phi$  is the azimuthal angle about the incident beam direction of the normal to the scattering plane and  $\phi = 0$  corresponds to having the scattering plane perpendicular to the camera axis; (c) the region  $0.9 < \cos \theta < 1$  was rejected as unreliable at all three momenta and the region  $-1 < \cos \theta < -0.9$  was rejected at 864 and 969 MeV/c. In the remaining regions of  $\cos \theta$  the corrections for scanning loss were always less than 6%.

The final results are given in Table I and plotted in Fig. 1, along with published data at other momenta.<sup>1, 5, 12</sup> The data of Carroll et al. at 1.20 BeV/c are shown with ours in Fig. 1e. The data of Carroll et al. are lower than ours by a factor of  $0.64 \pm 0.05$ , and we see no way in which such a bias could have occurred in our data. We thus conclude that the absolute normal-

ization of the data of Carroll et al. at this momentum is probably incorrect. We have performed Legendre-polynomial fits to elastic scattering data up to 1960 MeV/c, and the resulting coefficients are plotted as a function of beam momentum in Fig. 2. The only clear structure in the 800-1400-MeV/c transition region is a small negative dip in both  $a_1$  and  $a_3$  near 900 MeV/c. The Legendre fits have been used to calculate the differential cross section in the forward and backward directions, as given in Table I. The forward differential cross section can be used in conjunction with the optical theorem<sup>13</sup> to obtain the real and imaginary parts of the forward  $K^+p$  scattering amplitude. Carter<sup>14</sup> has used dispersion relations to calculate the real part of the forward scattering amplitude, and we can compare our results with his. He predicts for the center-of-mass forward scattering amplitude  $\text{Re } f(0) = -0.25 \pm 0.03$ ,  $-0.24 \pm 0.03$ , and  $-0.28 \pm 0.03$  fm, at 864, 969, and 1207 MeV/c, to be compared to our measured values of  $\text{Re } f(0) = -0.26 \pm 0.03$ ,  $-0.25 \pm 0.04$ , and  $-0.24 \pm 0.03$ , in good agreement.<sup>15</sup>

In conclusion we find the  $K^+p$  elastic scattering to undergo a smooth transition from low-energy S-wave scattering to a forward diffraction peak, with minimal structure as a function of energy.

We would like to acknowledge the help of Howard S. White and the Data Handling Group, the Bevatron staff, and the 25-inch bubble chamber crew, as well as the efforts of our scanning, measuring, and computing staff. Dr. Michael G. Bowler, Dr. John L. Brown, and Dr. Sulamith Goldhaber participated in the early phases of this experiment, and Dr. Charles G. Wohl has contributed advice and helpful discussions.

FOOTNOTES AND REFERENCES

\*Work supported by the U. S. Atomic Energy Commission.

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12. S. Focardi, A. Minguzzi-Ranzi, L. Monari, G. Saltini, P. Serra, T. A. Filippas, and V. P. Henri, Physics Letters 24B, 314 (1967).
13. For the total  $K^+p$  cross section at 864, 969, and 1207 MeV/c we use  $13.62 \pm 0.30$ ,  $15.35 \pm 0.22$ , and  $18.32 \pm 0.12$ , as interpolated from the data of Refs. 9 and 10.
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15. We do not measure the sign of  $\text{Re } f(0)$ , but choose the same sign as that measured at lower momenta by S. Goldhaber et al., Ref. 1.



Table I. Number of events and differential cross section for  $K^+p$  elastic scattering; the values of  $d\sigma/d\Omega$  at  $\cos\theta = \pm 1$ , given in italics, come from the Legendre fits described in the text.

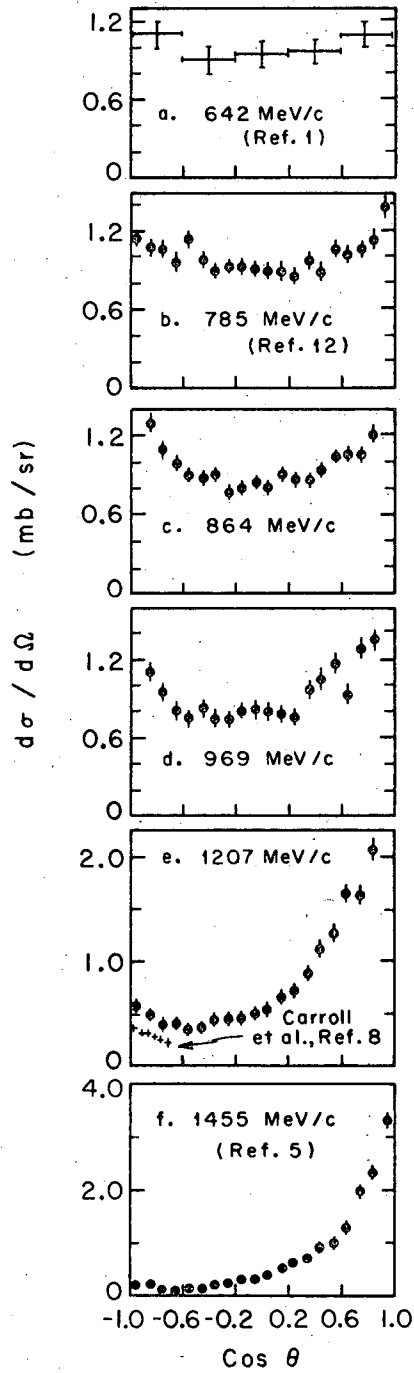
$\cos\theta$	864 MeV/c		969 MeV/c		1207 MeV/c	
	events	$\frac{d\sigma}{d\Omega}$ (mb/sr)	events	$\frac{d\sigma}{d\Omega}$ (mb/sr)	events	$\frac{d\sigma}{d\Omega}$ (mb/sr)
<u>-1.0</u>		<u>1.60±0.12</u>		<u>1.37±0.16</u>		<u>0.57±0.07</u>
-1 to -0.9	485±27 <sup>a</sup>		238±19 <sup>a</sup>		165±18	0.57±0.06
-0.9 to -0.8	535±24	1.30±0.06	256±18	1.10±0.08	141±14	0.49±0.05
-0.8 to -0.7	454±23	1.10±0.06	221±16	0.95±0.07	110±14	0.38±0.05
-0.7 to -0.6	409±22	0.99±0.05	189±16	0.81±0.07	118±15	0.41±0.05
-0.6 to -0.5	372±21	0.90±0.05	176±15	0.75±0.06	100±14	0.35±0.05
-0.5 to -0.4	357±21	0.87±0.05	193±16	0.83±0.07	108±13	0.37±0.05
-0.4 to -0.3	377±21	0.91±0.05	172±15	0.74±0.06	125±13	0.43±0.05
-0.3 to -0.2	316±19	0.77±0.05	172±15	0.74±0.06	130±15	0.45±0.05
-0.2 to -0.1	328±20	0.80±0.05	188±15	0.81±0.06	134±14	0.46±0.05
-0.1 to 0	350±22	0.85±0.05	192±16	0.82±0.07	147±16	0.51±0.06
0 to 0.1	335±20	0.81±0.05	185±15	0.79±0.06	157±17	0.54±0.06
0.1 to 0.2	378±22	0.92±0.05	184±15	0.78±0.06	192±17	0.66±0.06
0.2 to 0.3	360±21	0.87±0.05	176±15	0.76±0.06	204±16	0.71±0.06
0.3 to 0.4	357±21	0.86±0.05	225±16	0.96±0.07	255±17	0.88±0.06
0.4 to 0.5	389±22	0.94±0.05	244±17	1.05±0.07	325±19	1.12±0.07
0.5 to 0.6	431±22	1.04±0.05	272±18	1.17±0.08	368±22	1.27±0.08
0.6 to 0.7	436±24	1.06±0.06	218±16	0.93±0.07	476±24	1.65±0.08
0.7 to 0.8	437±24	1.06±0.06	299±19	1.28±0.08	470±23	1.63±0.08
0.8 to 0.9	499±26	1.21±0.06	315±19	1.35±0.08	598±28	2.07±0.10
0.9 to 1.0	340±25 <sup>a</sup>		260±20 <sup>a</sup>		536±32 <sup>a</sup>	
<u>1.0</u>		<u>1.34±0.13</u>		<u>1.62±0.17</u>		<u>2.54±0.16</u>

a. These bins are unreliable; see text.

FIGURE CAPTIONS

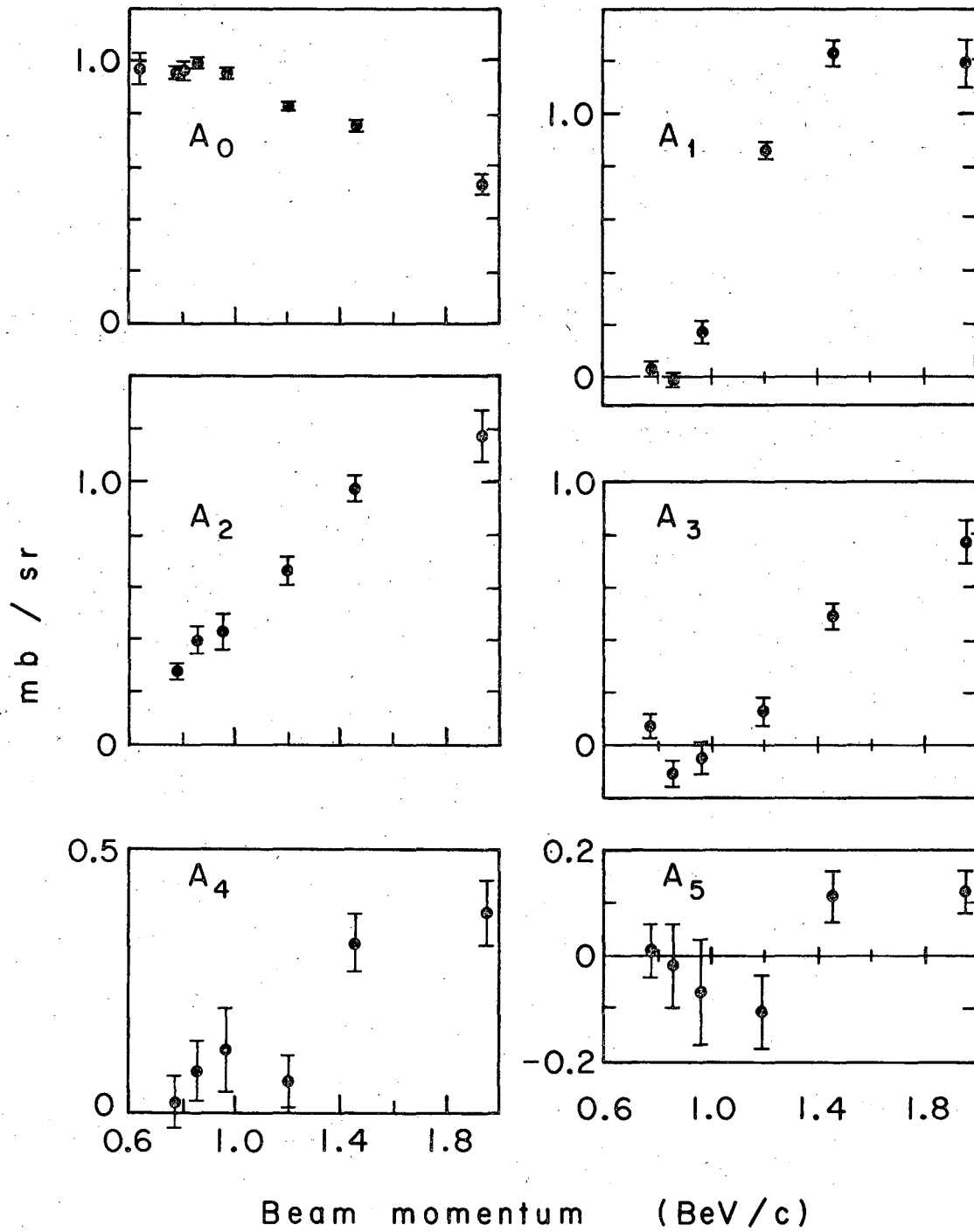
Fig. 1. The differential cross section for  $K^+p$  elastic scattering from 642 to 1455 MeV/c.

Fig. 2. Legendre coefficients for  $K^+p$  elastic scattering as a function of beam momentum;  $d\sigma/d\Omega = \sum_{\ell} A_{\ell} P_{\ell}(\cos \theta)$ .



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Fig. 1



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Fig. 2

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