K^-p ELASTIC SCATTERING AT 2.00 BeV/c

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A study has been made of K^-p interactions at 2.00 BeV/c obtained in the 20-in. bubble chamber at the separated K^- beam of the Brookhaven AGS. The K^- momentum was defined to ±20 MeV/c. About 100 000 photographs were obtained, averaging 6.2 beam tracks each. The purity of beam was estimated as 100% with a statistical error of 9.6% from the number of τ decays found in 1/5 of the total number of pictures. All events were analyzed using the DATPRO program of Adair and Leipuner built around the GUTS kinematical mass fit program.[1]

The scanning efficiency for low-energy protons was estimated as a function of proton energy from a scatter plot of observed azimuthal angle versus scattering angle with respect to the forward direction. Areas of low proton population began to occur at $\cos\theta_{\rm bar} < -0.75$, indicating decreased scanning efficiencies for short proton recoils moving toward or away from the cameras.

The numbers of events in each angular interval between $-1.00 < \cos\theta_{\rm bar} < -0.75$ were corrected by the scanning efficiencies evaluated from the scatter plot. The number of events missed from a sample of 1055 events observed was estimated to be 583, giving a total of 1638. The total number of observed events of all other kinds accompanying this number of elastic scatters was 4849. Of these, 255 were characterized by no prongs and one "vee." It was estimated that 119 more of these were not seen, taking into account the distribution of events throughout the chamber. Then the ratio of the elastic to total cross section is $R = 1638/6698 = 0.245 \pm 0.007$. The best value of the total K^-p cross section was found to be 30.4 ± 1.0 mb by fitting a smooth curve through values[2,3] from 1 to 20 BeV/c. The elastic scattering cross section is computed to be $\sigma_{\rm el} = R\sigma_{\rm tot} = 7.46 \pm 0.30$ mb. This value may be compared with[4] 4.23 ± 0.85 mb at 7.2 BeV/c, with[5] 12.0 $\pm$ 1.0 mb at 1.4 BeV/c.

From all the film, 2368 elastic scatters were measured and corrected in the way discussed above, leading to a total of 3773. The differential scattering cross sections, computed by normalizing the total corrected number to 7.46 mb, are listed in Table I, and plotted in Fig. 1.

The accepted events showed a distribution of the χ^2 probability function appropriate to a four-constraint requirement on the energy and momentum relations.

Small-angle scatterings almost always had only one mass fit, whereas larger angle elastic scatterings frequently had acceptable χ^2 values for mass fit as $K^-p\pi^0$. Visual inspection for compatibility of observed with computed ionizations removed most ambiguous interpretations. For example, for barycentral scattering angles of

Table I. Differential elastic scattering cross section for 2-BeV/c K^- on p.

Barycentral $\cos\theta(K^-)$	Number of events uniquely identified as elastically scattered	Number of ambiguous events	Elastic scattering cross section (mb/sr)
1.00-0.95	1650	6	10.39 ± 0.45
0.95-0.90	801	5	5.05 ± 0.21
0.90-0.85	423	6	2.66 ± 0.14
0.85-0.80	272	12	1.71 ± 0.11
0.80-0.75	133	7	0.84 ± 0.08
0.75-0.70	75	6	0.47 ± 0.05
0.70-0.65	48	10	0.30 ± 0.04
0.65-0.60	38	9	0.24 ± 0.04
0.60-0.55	24	5	0.151 ± 0.032
0.55-0.50	16	8	0.100 ± 0.025
0.50-0.40	36	9	0.113 ± 0.019
0.40-0.30	18	4	0.056 ± 0.013
0.30-0.20	28	5	0.088 ± 0.016
0.20-0.10	23	15	0.072 ± 0.016
0.10-0.0	29	12	0.091 ± 0.016
0-(-0.10)	33	13	0.104 ± 0.019
(-0.10)-(-0.20)	21	7	0.066 ± 0.013
(-0.20)-(-0.30)	16	8	0.050 ± 0.013
(-0.30)-(-0.40)	23	9	0.072 ± 0.016
(-0.40)-(-0.50)	17	10	0.054 ± 0.013
(-0.50)-(-0.60)	19	8	0.060 ± 0.013
(-0.60)-(-0.70)	9	4	0.028 ± 0.009
(-0.70)-(-0.80)	7	2	0.022 ± 0.009
(-0.80)-(-0.90)	6	2	0.019 ± 0.006
(-0.90)-(-1.00)	8	4	0.025 ± 0.009

greater than 90°, 159 events were uniquely identified as K^-p, and only 67 events ambiguously identified as $K^-p\pi^0$ and K^-p. For scattering angles in the forward hemisphere, there were 3614 K^-p events and 119 ambiguous events. These have been listed in Table I (not shown in the figure) but outside of the diffraction peak they are almost isotropically distributed. Comparison of the χ^2 distribution for the $K^-p\pi^0$ fits with the distribution for an accepted sample of $K^-p\pi^0$ indicates that about 75% of the ambiguous events are elastic.

The extrapolated value of the differential scattering cross section at zero degrees is 13.0 mb/

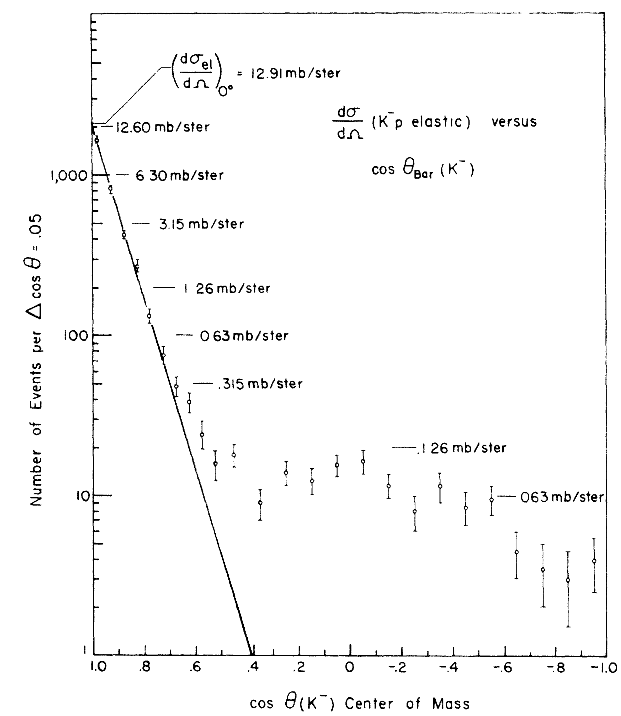

FIG. 1. Differential elastic scattering cross section found in this experiment for 2.00-BeV/c K^-p, in mb/sr, plotted versus $\cos\theta(K^-)$ in barycentral system. The errors shown on this plot are determined from $N^{1/2}$ where N is the number of events in each interval of $\cos\theta$, and do not include the experimental error in the value of total cross section from which the total scattering cross section has been determined.

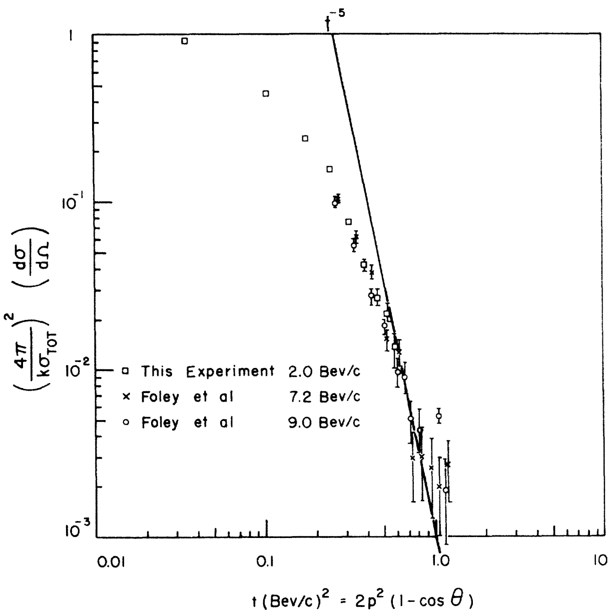

FIG. 2. Differential elastic scattering cross section found in this experiment expressed as $\{4\pi/k\sigma_{\text{tot}}\}^2 d\sigma/d\Omega$ together with similar data[4] at 7.2 BeV/c and 9.0 BeV/c, plotted versus square of total momentum transfer in the manner of Serber.[6] Within experimental error the same dependence is shown from 2.0 to 9.0 BeV/c as for p-p scattering.

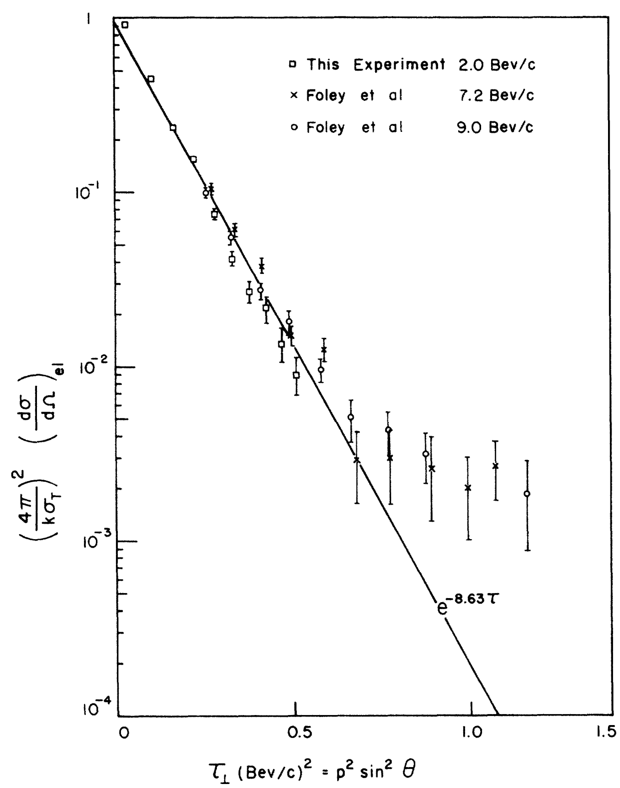

FIG. 3. Differential elastic scattering cross scattering cross section found in this experiment expressed as $(4\pi/k\sigma_{\text{tot}})^2 d\sigma/d\Omega$ together with similar data[4] at 7.2 BeV/c and 9.0 BeV/c plotted versus square of transverse momentum transfer in the manner of Krisch.[7] Within experimental error the same power dependence is shown from 2.0 to 9.0 BeV/c as for p-p scattering.

sr in agreement with the value computed from the optical model and found by extrapolation in a counter experiment for 1.95-BeV/c K^-p scattering by Cork et al.[2]

The diffraction cone of the present data expressed as $d\sigma/dt$ in terms of total momentum transfer squared $t = 2q^2(1 - \cos\theta)$, where q is the barycentral momentum, shows a dependence on t identical with diffraction data[3] at 7.23 and at 8.97 BeV/c within experimental error.

Our K^-p elastic scattering data are plotted in Fig. 2 in the manner of Serber.[6] He has shown that the diffraction cross section for pp scattering depends on the total momentum transfer as t^{-5} for seven decades of decrease. He explains this by a purely absorptive optical-model potential, $[i\eta \exp(-\Lambda r)]/r$, with a unique coupling strength η and variable range Λ, where η is determined by the ratio $\sigma_{\text{el}}/\sigma_{\text{tot}} = 0.23$ which holds for protons up to 30 BeV/c. The present data are consistent with the same model and the same coupling strength within experimental error. But the range is related to the total cross section, which is different in this same energy region for pp and for K^-p scattering, and is evaluated as $\Lambda^{-1} = 0.312 \times 10^{-13}$ cm using the cross sections given above.

An interesting variant on the optical model is that of Krisch[7] who finds that pp elastic scattering depends on the transverse momentum transfer $t = q^2 \sin^2\theta$ with two power laws, the first of which corresponds to the dependence found by Serber, and the second of which may be construed as evidence for pp scattering from an inner core. He studied the transverse momentum transfer because for identical particles (e.g., pp) it is invariant to a 180° rotation in the barycentral system. This reason is of course no longer applicable to scattering of non-identical particles (e.g., Kp).

In Fig. 3 is shown the K^-p differential elastic scattering dependence on transverse momentum transfer so far as present data plus those of reference 5 allow. The power law holding for small t is evident, but unfortunately the data presently available stop short at 1.0 (BeV/c)^2 transverse momentum transfer where the break occurs between the first and second of two power dependences shown by *pp* scattering. Therefore the conclusion of Krisch, namely that the transverse momentum transfer is of fundamental importance for *pp* interactions, appears valid for *Kp* elastic scattering likewise. But as yet there is no evidence that the core potential of *pp* scattering also exists in *Kp* scattering.

The dependence of *Kp* scattering on a power of the transverse momentum transfer is of different significance than the dependence on a power of the total momentum, because the dependences are demonstrated over a range of incident K^- momenta (2 BeV/*c* to 9 BeV/*c*) so that total momentum transfer and transverse momentum transfer do not have a one-to-one correspondence.

The increase of elastic scattering at backward angles observed for 1.04-BeV/*c* K^-p scattering[3] is not apparent at 2.00 BeV/*c*.

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APPROXIMATE UNITARY SYMMETRY AND THE PARITY QUESTION

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By the parity question is meant, why is parity conserved in strong and electromagnetic but not in weak interactions? One may not consider this to be a physical question at all, but just a descriptive fact. It seems more natural, however, to assume (a) that there is a univeral law involving parity, (b) that there are characteristic properties of strong and electromagnetic interactions which lead to *P* conservation, and (c) that the weak interactions do not have such properties. This is the view adopted here. Specifically it is assumed that[1] *CP* is the universal law. It will be asked whether approximate unitary symmetry together with considerations of gauge invariance and minimality of interactions are sufficient grounds for answering the parity question. It will be found that this line of reasoning (1) restricts certain forms of interaction within SU(3) and (2) gives an independent discrimination against certain other symmetry groups.

Attempts in this direction are not new.[2-6] It will help for what follows to recall a few results from this earlier work. First, consider strong trilinear baryon meson interactions between $(N, \Lambda, \Sigma, \Xi)$, their antiparticles, and (π, K). Assume that these are minimal (no derivatives occur) and satisfy *CP* only. Then ask if there exists a minimum sufficient invariance which combined with *CP* yields *C*/*P*. The answer is

$$\text{for } (NN\pi), (\Xi\Xi\pi)\text{: charge symmetry;}$$
$$\text{for } (\Sigma\Sigma\pi)\text{: charge independence;} \qquad (1)$$