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MEASUREMENT OF THE REAL PART OF THE FORWARD ELASTIC NUCLEAR AMPLITUDE FOR K^-p AT 16 GeV/c

by

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ABSTRACT

The differential cross section for the K^-p elastic scattering at 16 GeV/c in the range $0 < |t| \leq 0.4$ GeV^2 is obtained. In the t-range up to 0.1 GeV^2 the ratio ρ of the real to the imaginary part of the nuclear amplitude and the slope parameter are measured. For the other t-range a conventional exponential fit is used in order to determine the slope parameter. A comparison between ρ and theoretical predictions from dispersion relations is made.

1. INTRODUCTION

We have investigated the elastic scattering of K^- mesons on protons for small momentum transfers $(0.01<|t|<0.4)\,GeV^2$. We have taken into account the Coulomb amplitude. It is comparable in strength to the nuclear amplitude in the range $(0.01<|t|<0.1)\,GeV^2$, giving rise to interference effects. In this way we could determine both the magnitude and sign of the real part of the scattering amplitude, at small values of t.

Through the determination of the ratio ρ of the real to the imaginary part of the forward elastic amplitudes for different incident energies[1-10], the validity of forward dispersion relations can be checked[11-14].

This paper presents our determination of ρ for K^-p at 16 GeV/c (where, up to now, there is no information) from a sample of 41.332 elastic events(*) observed in the CERN 2m hydrogen bubble chamber.

In Sect. 2 we describe the method that we used to treat the data sample at very small values of t. In Sect. 3 we give the differential cross section and we discuss the parametrization used to determine ρ. Sect. 4 contains the comparison between our experimental result with the dispersion relation curve.

(*) We thank Prof. G. Otter and the members of the Aachen-Berlin-CERN-London-Vienna Collaboration who made these data available to us.

2. THE TREATMENT OF THE DATA

In order to correct for scanning and measurement losses of events at small values of t (up to 0.2 GeV^2), we have made a scatter diagram for each t interval plotting the momentum distribution of the scattered K^- mesons in the (p_y, p_z) plane perpendicular to the beam direction. In this way, all the events with a momentum p_y smaller than a limiting value p_c (cut-off) has been geometrically corrected on basis of cylindrical symmetry around the beam direction.

Fig. 1 shows an example of such a scatter diagram for the $|t|$ interval 0.040 to 0.045 GeV^2.

3. PARAMETRIZATION OF THE DIFFERENTIAL CROSS SECTION

The differential cross-section $d\sigma/dt$ (Fig. 2) has been obtained by normalization to the observed value of the integrated elastic cross section $\sigma_{el} = 2.77 \pm 0.17$ mb[15].

Following ref. [3], we have taken the Coulomb amplitude as

$$F_c(t) = 2\alpha\hbar\sqrt{\pi}\ \beta_L^{-1}\ e^{2i\delta}\ e^{-\frac{1}{2}b|t|}\ |t|^{-1} \qquad (1)$$

where α is the fine structure constant, β_L is the velocity of the K^- meson in the laboratory system, b is the slope parameter (the same for the nuclear amplitude) and δ is the model-dependent phase of the Coulomb amplitude[16] given by

$$\delta = -(\ell n|t| + \ell n b + 0.577)\alpha(2\beta_L)^{-1} \quad . \qquad (2)$$

The nuclear amplitude is taken as

$$F_N(t) = \sigma_t \; (4\sqrt{\pi}\,\hbar c)^{-1}(\rho+i)\; e^{-\frac{1}{2}b|t|} \qquad (3)$$

where σ_t is the total K^-p cross section at 16 GeV/c and

$$\rho = \mathrm{Re}\, F_N(0)/\mathrm{Im}\, F_N(0) \quad . \qquad (4)$$

σ_t is related to the imaginary part of the forward nuclear amplitude through the optical theorem.

The differential cross section is given by

$$\frac{d\sigma}{dt} = |F_C+F_N|^2 = \left(\frac{d\sigma}{dt}\right)_C + \left(\frac{d\sigma}{dt}\right)_N + \left(\frac{d\sigma}{dt}\right)_I \qquad (5)$$

where C, N and I represents Coulomb, Nuclear and Interference terms. Taking F_c and F_n as defined above we have

$$\left(\frac{d\sigma}{dt}\right)_C = 2.60945 \times 10^{-4}\; t^{-2}\; e^{-bt} \qquad (6)$$

$$\left(\frac{d\sigma}{dt}\right)_N = 23.8820\; (1+\rho^2)\; e^{-bt} \qquad (7)$$

and

$$\left(\frac{d\sigma}{dt}\right)_I = 0.157884\; t^{-1}\; (\rho\cos 2\delta - \sin 2\delta)e^{-bt} \quad . \qquad (8)$$

We have determined values of the parameters ρ and b (assuming them to be independent) by making a least squares fit in the range $(0.01 < |t| < 0.1)\mathrm{GeV}^2$. We have obtained the values

$$\rho = 0.123 \pm 0.096$$

and

$$b = 9.50 \pm 0.65 \text{ GeV}^{-2} \quad .$$

The value of the differential cross section for the first t bin was not taken in the fit due the fact that the scanning loss corrections are not reliable.

For $0.1 < t \leq 0.4$, the contribution of the Coulomb scattering is small and can be neglected. We have fitted the data in this region by a simple exponential e^{-Bt}. We have found the value

$$B = 7.04 \pm 0.23 \text{ GeV}^{-2} \quad .$$

In Fig. 3 a and b we show the curve of our fit for these two regions of t, respectively.

4. CONCLUSIONS

As we can see in Fig. 4, our result for ρ agrees well with the prediction given by dispersion relations[17,18].

We have found a change of slope in the $d\sigma/dt$ distribution around $|t| \sim 0.1$ GeV^2. This was also observed by Campbell et al. at 10.1 GeV/c.

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FIGURE CAPTIONS

FIG. 1. – Scatter diagram of the momentum distribution of the scattered K^- mesons in the (p_y, p_z) plane for the t-bin 0.040 to 0.045 GeV^2.

FIG. 2. – K^-p elastic differential cross section at 16 GeV/c after scanning and measurement corrections.

FIG. 3.a – K^-p elastic differential cross section at 16 GeV/c for $0 < |t| \leq 0.1$ GeV^2. The line is our fit with $\rho = 0.123 \pm 0.096$ and $b = 9.50 \pm 0.65$ GeV^{-2}.

3.b – K^-p elastic differential cross section at 16 GeV/c for $0.1 < |t| \leq 0.4$ GeV^2. The line is our fit with $B = 7.04 \pm 0.23$ GeV^{-2}.

FIG. 4. – K^-p ratio of forward real part to imaginary part. Experimental points are taken from the following references: ◇ our result; X Ref. [10]; △ Ref. [4]; ○ Ref. [8]; ▲ Ref. [6]; ● Ref. [9]; □ Ref. [1]; ■ Ref. [3]; ◆ Ref. [5]. The full line is the theoretical prediction from dispersion relations Ref. [17] and the dashed line Ref. [18].

Fig. 1

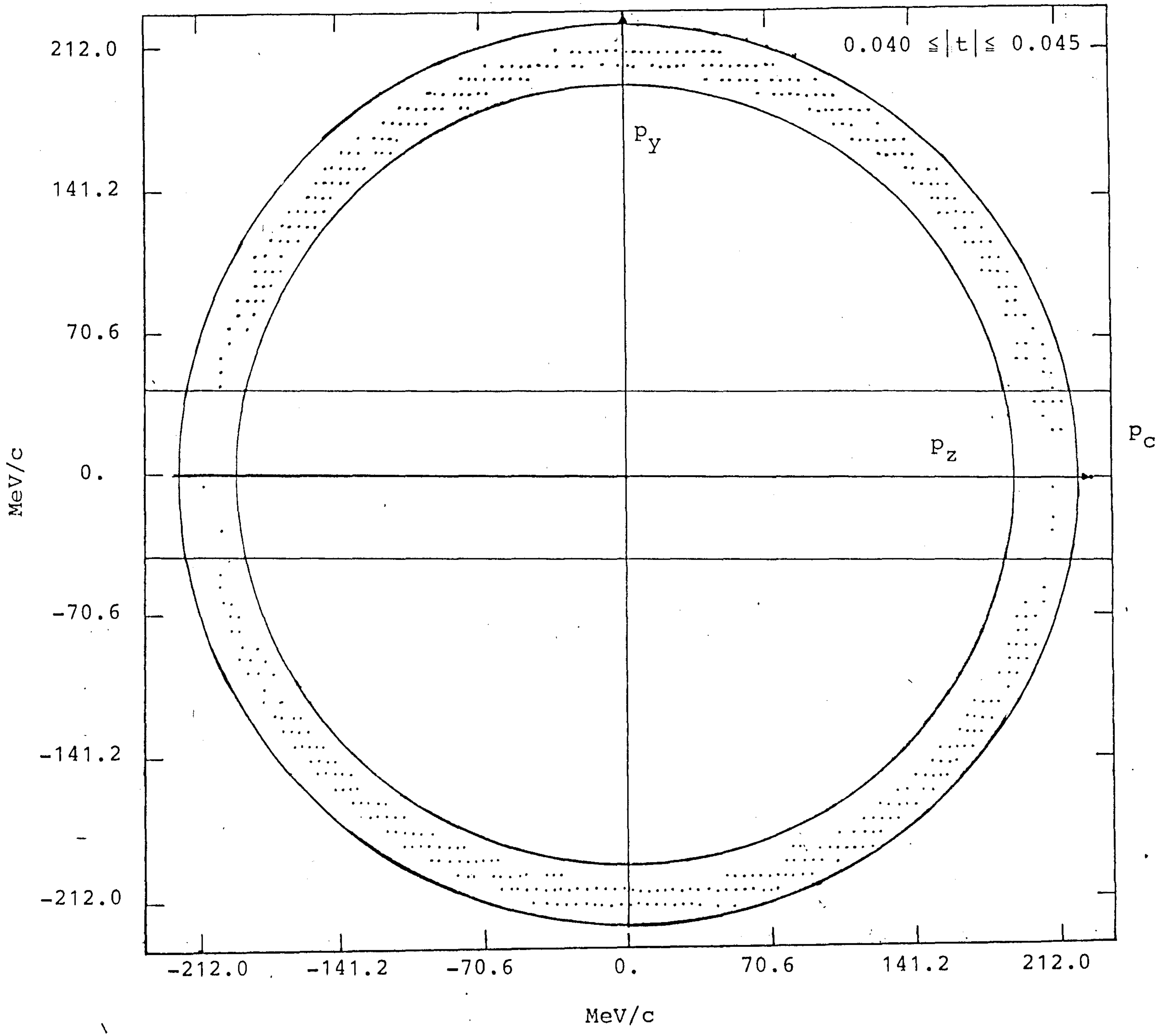
0.040 ≦ |t| ≦ 0.045
p_y
p_z
p_c
212.0
141.2
70.6
0.
-70.6
-141.2
-212.0
-212.0
-141.2
-70.6
0.
70.6
141.2
212.0
MeV/c
MeV/c

Fig. 2

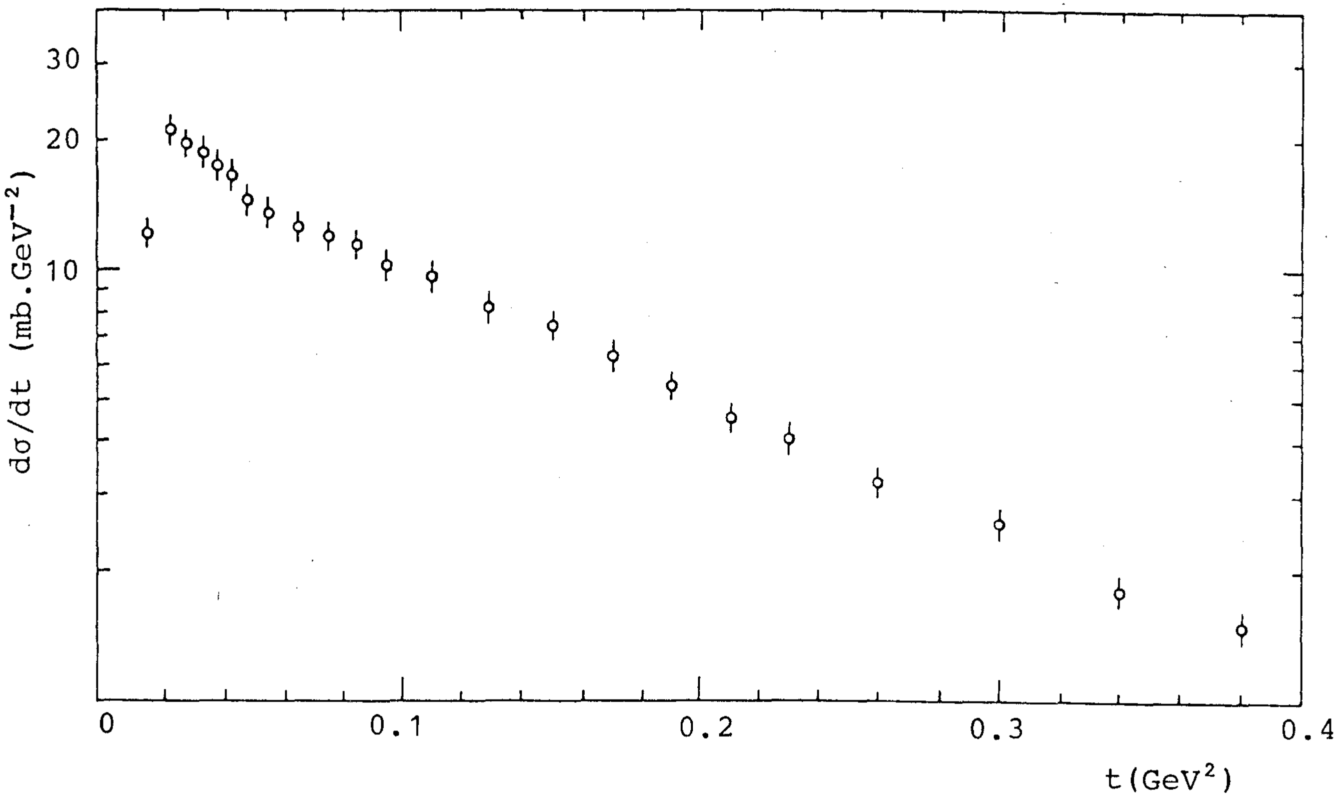

Fig. 3.a

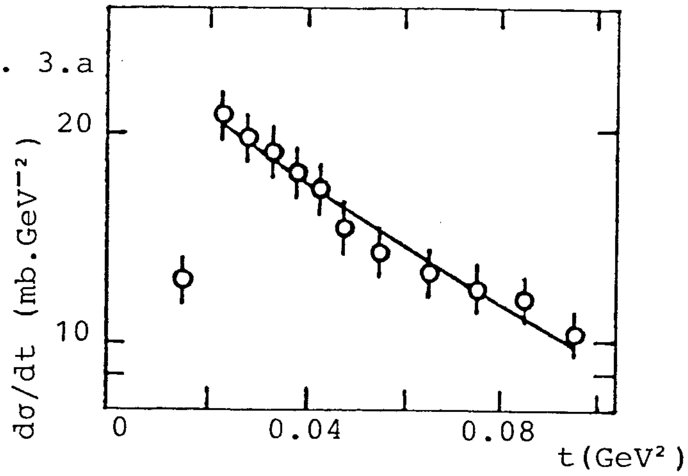
20
10
dσ/dt (mb.GeV⁻²)
0
0.04
0.08
t(GeV²)

Fig. 3.b

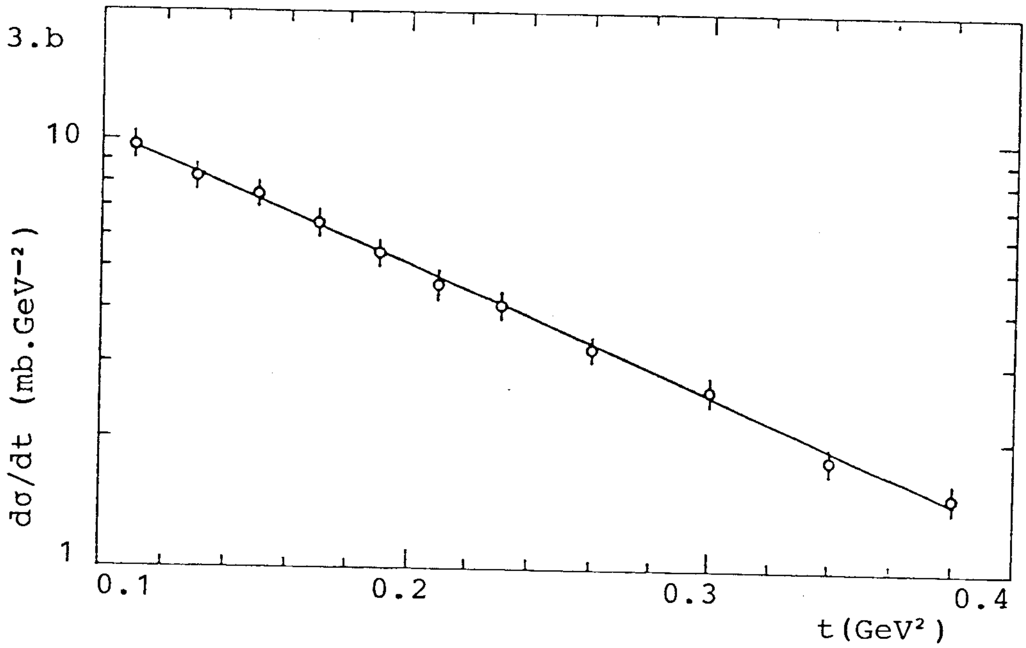
10
1
dσ/dt (mb.GeV⁻²)
0.1
0.2
0.3
0.4
t(GeV²)

Fig.4