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A MEASUREMENT OF THE REAL PART OF THE ELASTIC π^{-}-p SCATTERING AMPLITUDE AT 3.5 GeV

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A MEASUREMENT OF THE REAL PART OF THE ELASTIC π^--p SCATTERING AMPLITUDE AT 3.5 GeV

The data on the real part of the elastic $\pi^- - p$ scattering amplitude have been obtained from the experiment on the small angle scattering of pions on hydrogen. The experimental layout is shown in Fig. 1. In order to detect the slow recoil protons, a 50 x 50 x 15 cm magnetic cloud chamber filled with hydrogen up to 4 atmospheres was employed. About 10 thousand mesons with the (3.48 ± 0.05) GeV/c momentum passed through the chamber per expansion. The expansion coefficient of the chamber was such that the individual relativistic particle produced no track at all, while the whole beam left a pale line of fog. (see Fig.2). The recoil protons with a momentum up to 100 MeV/c were well seen in the beam, i.e., the ionization of such protons exceeded more than 40 times the minimum one. The methods of measurements and the analysis of the recoil proton tracks are described in /1/. The elastic events were identified according to the kinematical momentum-angle criterion for the recoil proton. The c.m. scattering angle was determined by the momentum of the recoil proton which was measured by the range or by the magnetic curvature with an accuracy of $\simeq 4\%$.

In order to determine the real part of the scattering amplitude, the recoil protons with the momentum $35 \leq p \leq 65$ MeV/c were selected. This range of momenta is most convenient for observing the interference of the Coulomb and nuclear amplitudes since here the $A_{Coulomb}$ and $A_{nuclear}$ are almost the same. The determination of the total pion flux through the chamber was made by means of the nuclear emulsion (Φ) overlapping the beam. The emulsion was exposed until the flux of about 10^5 cm^{-2} was available. For the measurements we made use of the microscope. The total flux was thus determined with an accuracy of 3.5%. Besides, using the integral electronic circuit (S) the pion flux was determined per pulse with an accuracy of 5%. The muon contamination of the beam was $(7 \pm 1)\%$, and the electron contamination was $(2.7 \pm 0.3)\%$.

15 thousand photographs were analysed. They were scanned with the aid of a 40 x 40 cm^2 reprojector. For the tracks with a projection of more than 0.8cm the efficiency of the triple scan was equal practically to 100 %. The efficiency of the single scan was 90%. The found events were measured twice on the half-automatic devices and computed by means of an electronic computer. The programme included a correction for geometry (an azimuthal correction). This correction depended upon the position of the proton in the chamber and upon its momentum. It was calculated separately for each event.

On the analysed photographs in the corridor of $\pm$ 10° from the kinematical momentum-angle line there were found 133 tracks of the recoil protons, whose momentum transfers squared were $1.22^{-3} \leq t \leq 4.22.10^{-3}\,GeV^2/c^2$. Fig.3 shows the distribution of those recoil protons by their mangitude of deviation from the kinematical curve $\Delta = \theta - \theta_{kin}$. Here θ is the measured angle, θ_{kin} is the angle calculated by the kinematics from the value of the measured momentum. The maximum in the distribution exceeding the background level as much as about 5 times corresponds to the elastic $\pi^{-}p$ scattering events. The elastic scattering cross section calculated after the background subtraction was found to be $\Delta\sigma = 0{,}225 \pm 0.039$ mb in this range of momentum transfers. The value obtained was compared with the cross section theoretically calculated for different $a = \frac{Re\,A}{Im\,A}$. The calculation was carried out by the Bethe formula/2/. The value of the imaginary part of the scattering amplitude at 0° was taken starting from the value for the total $\pi^{-}-p$ interaction cross section $\sigma_{tot} = (31.3 \pm 0.2\ )$ mb /3/. To the value $\Delta\sigma = \int_{1.22.10^{-3}}^{4.22.10^{-3}} \frac{d\sigma}{dt}\,dt = (0.225 \pm 0.039)$ experimentally obtained, there corresponds $a = -(0.33 \pm^{0.32}_{0.19})$.

Fig. 4 shows the differential cross section for elastic $\pi^{-}-p$ scattering. The solid curve was drawn according to the Bethe formula for the case of the absence of interference. The experimental points in the interference region are located below it, i.e., a destructive interference is observed. Just as for pp - scattering/5/, to the real part of the scattering amplitude there correspond the forces having a repulsive character.

In paper/6/, a calculation of the real part of the elastic $\pi^{-}-p$ forward scattering amplitude was made using the dispersion relations. For the negative pion energy of 3.5 GeV, a value of $a = -0.20$ /6/ was obtained. Thus, the sign and the magnitude of the real part of the scattering amplitude is in agreement with the dispersion relations.

The principal error in determinaing a is the statistical one. The data published concern only a part of the material available. In this sense we are treating them as preliminary.

We would like to thank V.I.Veksler for his constant attention to the experiment and all those who assisted during the exposures in the beam and participated in the analysis of the data.

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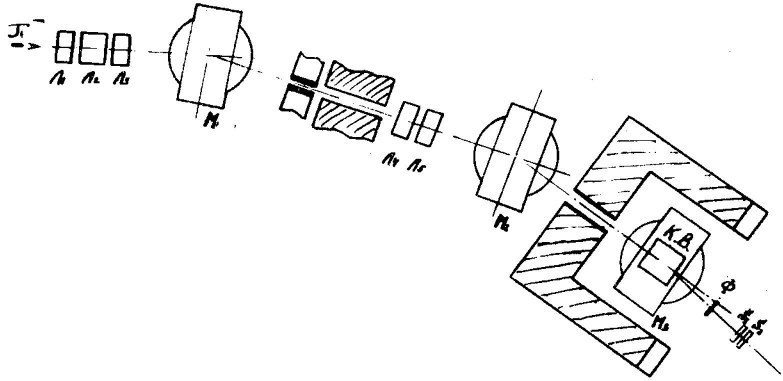

Fig.1. Experimental setup. The notations: Λ_{1-5} are the magnetic lenses, $M_{1,2,3}$ are the bending and chamber magnets, Φ is the photoemulsion monitor, $S_{1,2}$ are the electron monitors.

Fig.2. The track of the recoil proton with a momentum of about 100 MeV (the ionization is by a factor of 40 greater than the minimum one). For the calculation of the cross section the tracks in the momentum interval of $35 \lesssim p \lesssim 65$ MeV/c were selected which has an ionization exceeding the minimum one by a factor of more than 30.

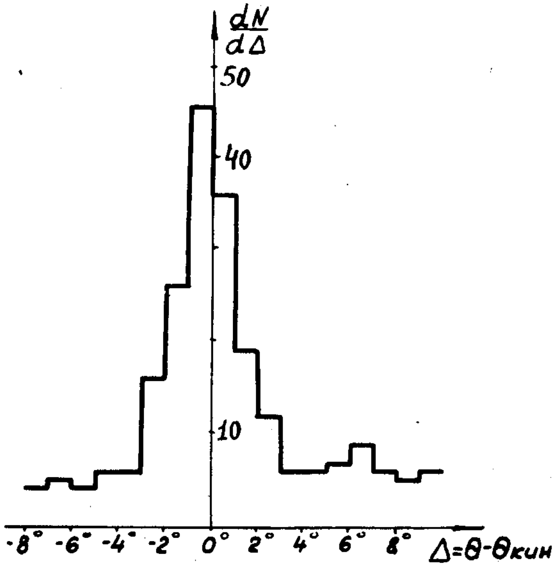

Fig.3. The distribution of the recoil protons by the value of the deviation from the kinematics.

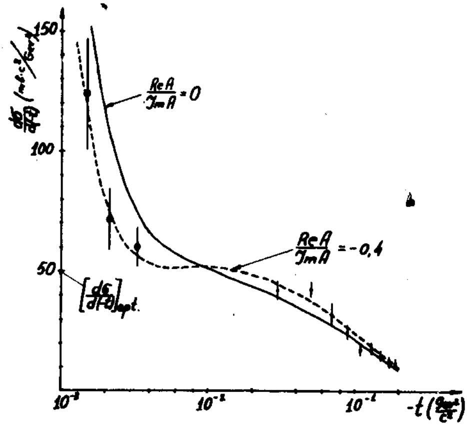

Fig.4. The differential cross section for elastic $\pi^- p$ scattering. ϕ is the present experiment. ϕ were obtained from the data of paper /4/.