Measurement of the polarization parameter P in elastic $\pi^{\pm}p$ scattering at 450 MeV

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The polarization parameter in elastic πp scattering was measured in a wide range of angles at 450 MeV both for negative and positive ions. The results are compared with the data obtained from various phase-shift analyses, and are also discussed from the point of view of isospin invariance.

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Measurements of polarization parameters in elastic πp scattering are a part of a general program for the investigation of pion-nucleon scattering in the region of the low-lying resonances, a program realized in the High-Energy Physics Laboratory of our Institute. In this paper we present the results of the measurements of the polarization parameter P at a pion energy 450 MeV. The measurements were performed by the method of secondary scattering of the recoil proton by the analyzer material. The energy was chosen because there are no experimental data in the range from 410 to 490 MeV, yet this range is of considerable interest, since serious discrepancies between different phase-shift analyses appear starting with approximately 450 MeV. The setup for the measurement of the polarization, described in detail in[1], consisted of 24 wire spark chambers with magnetostriction pickoff of the information for the determination of the spatial positions of the

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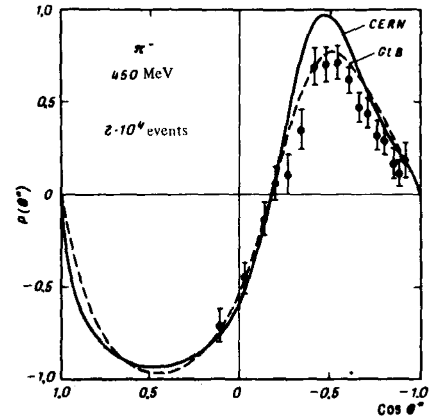

FIG. 1. Results of measurements of the parameter P in elastic $\pi^- p$ scattering at 450 MeV. The curves show the polarization values predicted by the CERN-EXP phase-shift analysis (solid curve) and the Glasgow B phase shift analysis (dashed).

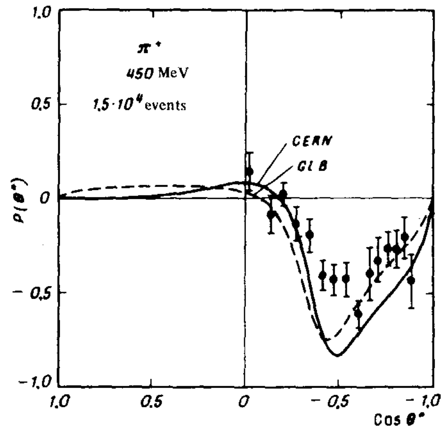

FIG. 2. The same as in Fig. 1, but for $\pi^+ p$ scattering.

scattered-particle trajectories and a temporal-analysis system for the determination of the times of flight of these particles.

The apparatus was used on line with a "Minsk-22" computer. During the course of the experiments, the operation of the spark chambers was monitored continuously, namely, for each chamber we determined the total efficiency and separately the efficiency of the information pickup from the high-voltage and grounded electrodes, and also the number of many-spark events and breakdowns along the old track. In addition, part of the statistical material was used for a preliminary calculation of the polarization.

The final reduction of the information was carried out with the "Minsk-32" computer after the end of the experiment. We first separated those events for which the points of intersection of the pion and proton trajectories were inside the hydrogen target. We then selected cases of elastic scattering of pions by protons; the selection was based on three parameters: the polar (θ) and azimuthal (ϕ) scattering angles, and the time of flight (τ). For each of these parameters we constructed the distributions of the numbers of events as functions of the differences $\Delta\theta$, $\Delta\phi$, and $\Delta\tau$ between the measured values and the values calculated on the basis of the equations of elastic kinematics. The distributions had a Gaussian form with the following standard deviations: $\sigma_\theta = 10$ mrad, $\sigma_\phi = 14$ mrad, and $\sigma_\tau = 0.8$ nsec. The subsequent reduction included also events for which the deviations $\Delta\theta$, $\Delta\phi$, and $\Delta\tau$ did not exceed 2σ for the corresponding distribution.

The next step was to plot for the selected events the distributions of the number of recoil protons against the angle of their second scattering by carbon. At angles larger than 5—6°, this plot becomes smooth enough, so that small errors (on the order of 0.1°) in the determination of the angle cannot lead to a noticeable false asymmetry. To calculate the polarization, we used cases of second scattering through an angle $6° \leqslant \theta_2 \leqslant 15°$.

The measurement results are shown in Figs. 1 and 2. A typical value of the error is 0.06—0.08. Altogether we analyzed 2.5×10^6 cases of hydrogen scattering, of which 1.5% of the events, corresponding to the second scattering by carbon through an angle 6—15°, were used to calculate the polarization. The figures show curves corresponding to the data of two phase-shift analyses, performed at CERN[2] and in Glasgow.[3] We see, the experimental results agree better with the Glasgow-B solution. We note that this solution was obtained with the aid of a continuous phase-shift analysis, in which the function describing the energy dependence of each of the phase shifts was obtained from the entire aggregate of the experimental data in the range 200—1800 MeV. To the contrary, the CERN-EXP solution at 450 MeV is based only on the results of measurement of the differential and total cross sections; data at other energies were used only to chose from among all the possible solutions the one satisfying the criteria of smoothness of the energy dependence of the parameters. Better agreement of the experimentally measured values of P with the predictions of the Glasgow-B phase-shift analysis can offer evidence in favor of the fact that a continuous analysis ensures a greater accuracy of reproduction of the amplitude of pion-nucleon scattering.

A joint analysis of the results of the present paper and the available published data on the differential cross section for elastic scattering[4] and charge exchange[5] has shown that the aggregate of the quantities measured at 450 MeV satisfies the isospin-invariance conditions within the limits of errors. It should be noted at the same time that at scattering angles close to 180° the values of the polarizations $P^{(+)}$ and $P^{(-)}$ lie at the very boundary of the allowed region; this circumstance can be used to verify the mutual consistency of different experiments in which the cross sections and polarization parameters are measured.

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