Measurement of the polarization parameter P in elastic $\pi^- p$ scattering at energies of 490 and 600 MeV

V. S. Bekrenev, V. G. Gaditskii, A. I. Kovalev, S. P. Kruglov, A. A. Kulbardis, I. V. Lopatin, V. E. Popov, A. N. Prokof'ev, V. V. Sumachev, V. Yu. Trautman, E. P. Fedorova-Koval', and E. A. Filimonov

B. P. Konstantinov Institute of Nuclear Physics, USSR Academy of Sciences

(Submitted 18 December 1979)

Pis'ma Zh. Eksp. Teor. Fiz. **31**, No. 3, 197–201 (5 February 1980)

The results of a measurement of the polarization parameter P in elastic $\pi^- p$ scattering at energies of 490 and 600 MeV are presented. The experiment was performed in the π-meson channel of the LINP synchrocyclotron using a polarized proton target and spark chambers with magnetostrictive information output. The data obtained make it possible to reduce the phase analysis uncertainty and increase the accuracy of the determination of the parameters of the S_{11}, P_{11}, and D_{13} resonances.

PACS numbers: 13.75.Gx

Measurements of the polarization parameter P in the elastic $\pi^- p$ scattering at energies of 490 and 600 MeV have been conducted within the framework of the general πN-interaction research program in the high energy physics laboratory of the B. P. Konstantinov LINP of the USSR Academy of Sciences.

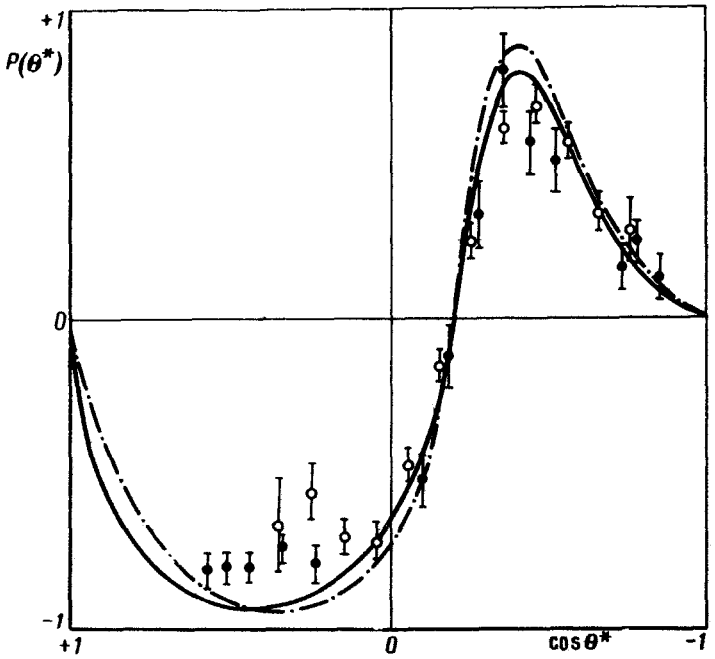

FIG. 1. Results of present work at energy of 490 MeV (dark circles) as compared with data of Ref. 5 (light circles). The angular dependences of the parameter, predicted by the CERN-72 (dot-dash) and LINP-78 (solid curve) phase analyses, are shown by the curves.

The experiment was conducted in the π-meson channel[1)] of the LINP synchrocyclotron using a polarized target (PT) of lanthanum-magnesium double nitrate; the average target polarization value was approximately 0.5. A package of four wire spark chambers, each 0.5×0.5 m^2 in size and providing a determination of particle direction within an accuracy of a few tens of degrees, served as the basic tracking element of the detecting equipment. Only five spark chamber packages were used in the experiment; the range of scattering angles encompassed by them corresponded to $\cos\theta^*$ from -0.9 to 0.6 in the c.m.s. The total covered solid angle amounted to ~0.7 steradian. A detailed description of the apparatus has been given in Refs. 1, 2.

In essence the experiment consisted of measuring the angular distributions of the scattered π-mesons and recoil protons for different polarization values of the PT. Since the PT contains only 3% (by weight) of free hydrogen, the background from inelastic events, associated with the scattering of π-mesons by the complex target and cryostat nuclei, is large. In order to ensure a correct subtraction of the background, measurements were made with a special hydrogen-free target-simulator (HFTS), duplicating the polarized target in size, mass and chemical composition.

A complete analysis of the data was performed on a BESM-6 computer after completion of the experiment. A total of about 8×10^5 cases of scattering by the PT and 4×10^5 cases of scattering by the HFTS were processed for each energy; 3×10^4 elastic events were identified. The data processing included the following steps: 1) re-

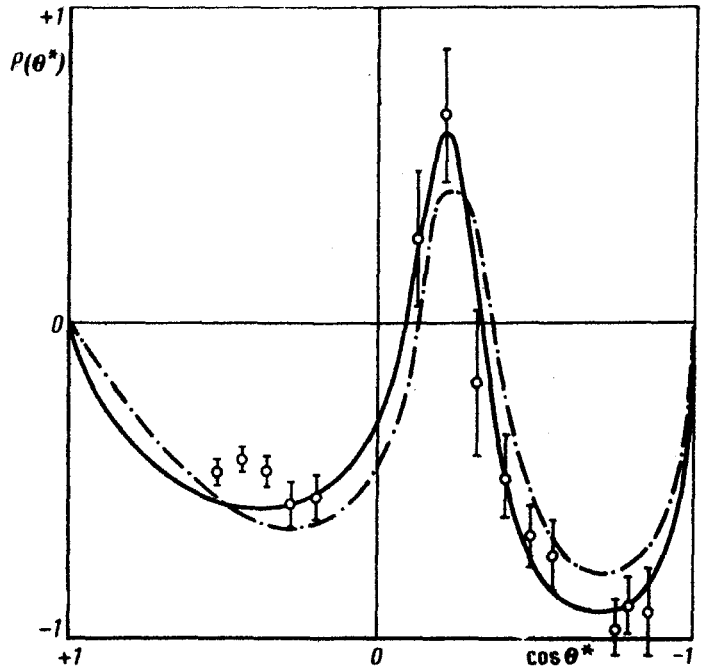

FIG. 2. Results of present work at energy of 600 MeV. Curve notations are same as in Fig. 1.

creation of the kinetics of each event; 2) isolation of events satisfying the elastic kinematic conditions; 3) calculation of the polarization parameter P. The kinematic reconstruction of the events was done by means of a direct tracing of the trajectories through the magnetic field; as a result, for each event we determined the coordinates of the scattering point and the departure angles of the scattered π-meson and recoil proton. Then events were selected for which the scattering point was located in the target region, and for these we plotted distributions in term of the deviation from angular kinematics ($\Delta\theta$) and from coplanarity ($\Delta\phi$); these distributions were also used to find the number of cases of elastic πp-scattering. To do this, the region, including the entire elastic peak, was isolated in the two-dimensional matrix $N(\Delta\theta, \Delta\phi)$, and the number of events, falling within this region for the measurements with the PT (N_+ and N_-, respectively, for the positive and negative signs of target polarization) and for the measurements with the HFTS, (N_d) was determined. The number of elastic events $H_\pm$ was then calculated as the difference of $N_\pm$ and N_d, and the numbers of events $M_\pm$, M_d, lying outside the isolated region of elastic kinematics: $H_\pm = N_\pm - N_d M_\pm / M_d$, were used for a relative normalization. Then the value of the polarization parameter P was determined in each angular interval using the known formulas (see, for example, Ref. 1).

The experimental results are shown in Fig. 1 and Fig. 2; only the statistical errors of the measurements[2)] are presented. Curves, plotted using the CERN-72[3] and LINP-78[4] phase analysis solutions, are also shown in the figures. There is good agreement

between the experimental data and those predicted by both phase analyses, although some preference can be assigned to the LINP-78 solution.

For comparison, Fig. 1 also shows the results of measurements made earlier at an energy of 490 MeV by the scattering method.[5] The excellent agreement of the data, obtained by the different methods in two independent experiments, is a definite indication of the absence of unaccounted for systematic errors. At the same time it must be stressed that we have obtained new information, unattainable when the double scattering method is used, for $\cos\theta^* > 0.3$. With regard to the 600-MeV energy, the low accuracy of previous experiments here prevented us from reaching any definite conclusion concerning the $P(\cos\theta^*)$ dependence; the data of our work have significantly smaller errors and allow us to state that in the interval $-0.3 < \cos\theta^* < -0.1$ an abrupt change occurs in the parameter P, accompanied by a double change in sign.

The use of these results in a new LINP phase analysis will make it possible to reduce its uncertainty and increase the accuracy of the determination of the parameters of the S_{11}, P_{11}, and D_{13} resonances. The authors plan to carry out this analysis after completion of the entire cycle of measurements of the parameter P in elastic $\pi^{\pm} p$ scattering within the range from 450 to 600 MeV.

[1)]The particle beam had a 6% momentum spread (total width at half-height); the accuracy of the determination of the average momentum value amounted to $\pm 0.5\%$.

[2)]There is an additional $\pm 3\%$ scale error, associated with the absolute normalization of the target polarization; it affects the determination of the scale of the parameter P and can therefore be considered to be systematic.

[1]V. S. Bekrenev, N. F. Bondar', V. G. Gaditskiĭ, A. I. Kovalev, S. P. Kruglov, L. A. Kuz'min, A. A. Kulbardis, I. V. Lopatin, V. E. Popov, A. N. Prokof'ev, V. V. Sumachev, V. Yu. Trautman, E. P. Fedorova-Koval' and E. A. Filimonov, Preprint LINP-466, Leningrad, 1979.

[2]V. S. Bekrenev, N. F. Bondar', V. G. Gaditskiĭ, S. P. Kruglov, A. A. Kulbardis, I. V. Lopatin, V. V. Sumachev, E. P. Fedorova-Koval' and E. A. Filimonov, Preprint LINP-401, Leningrad, 1978.

[3]S. Almehed and C. Lovelace, Nucl. Phys. B **40**, 157 (1972).

[4]V. V. Abaev, S. P. Kruglov and Yu. A. Malov, Preprint LINP-438, Leningrad, 1978.

[5]P. Bareyre, C. Bricman, M. I. Iongo, C. Vallads, G. Villet, G. Bisard, I. Duchen, I. M. Fontaine, C. P. Patry, I. Seguinet and I. Vonnet, Phys. Rev. Lett. **14**, 878 (1965).

Translated by Eugene R. Heath Edited by David Book