Measurement of the Polarization Parameter in Backward $\pi^+ p$ Elastic Scattering at 1.60, 1.80, 2.11, and 2.31 GeV/c *

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Measurements of polarization in $\pi^+ p$ elastic scattering have been made at 1.60, 1.80, 2.11, and 2.31 GeV/c. The data cover the entire angular range, with emphasis on the backward region. Comparisons have been made with both u-channel and t-channel models, as well as with predictions of phase-shift analyses. While the agreement is generally poor in all cases, the best agreement is with some t-channel predictions.

We report new measurements of the polarization parameter in $\pi^+ p$ elastic scattering at four incident pion momenta between 1.60 and 2.31 GeV/c. The data cover the center-of-mass angular range $-0.97 \leq \cos\theta_{c.m.} \leq 0.95$, with special emphasis on the very backward region.

The data were obtained in the course of a recent measurement of the polarization in $K^+ p$ elastic scattering at the Argonne National Laboratory zero-gradient synchrotron. The experimental setup and the procedures used were identical to those previously described,[1] except for two items: (A) Ethylene glycol was used as the polarized-proton target material, producing a target polarization between 40 and 45%; (B) improved precision in the backward-scattering data was obtained by the addition of a spherical Fitch-type Cherenkov counter filled with glycerol which responded to the forward-going protons while rejecting pions. The resulting increase in the signal-to-background ratio for backward events was a factor of 2 to 4.

The polarization data obtained at 1.60, 1.80, 2.11, and 2.31 GeV/c incident pion momentum are plotted in Fig. 1. The errors shown are statistical only and do not include any contribution due to the uncertainty in knowing the target polarization. In order to calibrate our electronic (NMR) method of determining the target polarization we have recently measured the polarization parameter in pp elastic scattering at 1.34 GeV/c. Our results were compared with polarization values obtained by Cheng et al.[2] in a double-scattering experiment at 1.34 GeV/c and by Albrow et al.[3] in a polarized-proton–target (lanthanum magnesium nitrate) experiment at 1.32 GeV/c. Our numbers at present indicate a discrepancy of about 10%, which we are investigating further. All polarization results given in this paper are based on the target polarization values as obtained by the NMR method.

Our measurements cover the region of dips in the differential $\pi^\pm p$ cross sections at $t \cong -0.6$ and -2.8 (GeV/c)^2, in the $\pi^+ p$ cross section at $u \cong -0.75$ (GeV/c)^2, and in the 180° $\pi^\pm p$ cross section at ~2 GeV/c incident momentum. At high energies the scattering process has been described separately at forward angles in terms of t-channel exchanges and at backward angles in terms of u-channel baryon exchanges. Our data lie in the intermediate energy region where a clear separation of t-channel and u-channel effects is difficult.

We have attempted to understand the qualitative features of these results in terms of other available data and current theoretical ideas and have made the following observations.

The data in the backward region are character-

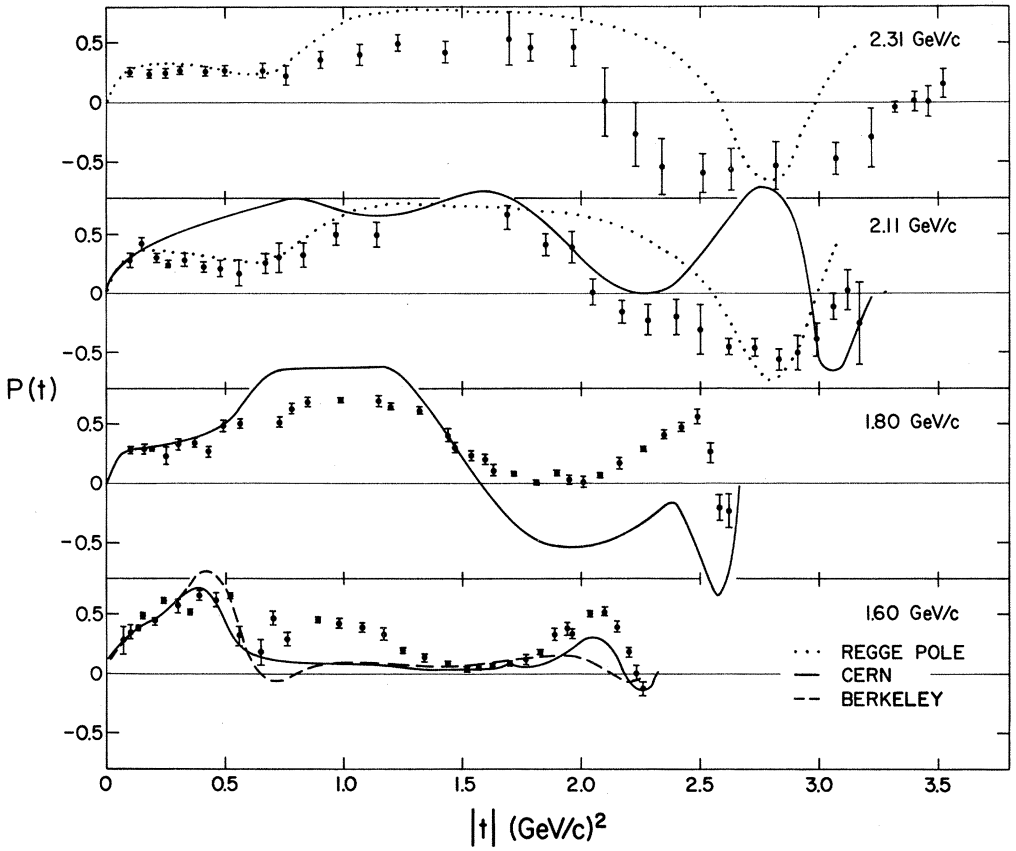

FIG. 1. π^+p polarization as functions of $|t|$ for incident momenta of 2.31, 2.11, 1.80, and 1.60 GeV/c. The Regge-pole prediction is based on Ref. 8, and the CERN and Berkeley phase-shift predictions are obtained from Ref. 9.

ized by large changes in the sign of polarization over a fairly small range of beam momentum. This is exhibited in Fig. 2, which shows the backward data replotted in terms of the variable u, together with other recent data at two higher momenta.[4] The cross-section data[5] show no such variation, except for an apparent loss of the dip at $u \cong -0.15$ (GeV/c)^2 around 2.0 GeV/c.[6] All existing baryon-exchange models,[7] with or without Regge cuts, predict small changes in polarization in this energy region, so they are inadequate in explaining these data. This is perhaps not very surprising, since they were intended to be applicable only in the high-energy region.

A comparison of the data with predictions of the t-channel Regge-pole model of Barger and Phillips,[8] which was also intended to be applicable only at higher energies, is shown by the dotted curves in Fig. 1. The agreement at the two higher momenta, 2.11 and 2.31 GeV/c, is reasonably good over the whole angular region. The agreement at 1.60 and 1.80 GeV/c is poor, however. Both of these curves have a zero at $u \simeq -0.6$ (GeV/c)^2, which is not reproduced in the Barger and Phillips predictions. We note that one difference between these two sets of data is that the two higher momenta are not near any large established resonance, while the two lower ones are in the vicinity of the $\Delta(1920)$.

We have also compared our results with predictions of the CERN and Berkeley phase-shift analyses.[9] The results are shown in Fig. 1. The agreement with the CERN results is perhaps better, but the overall agreement is poor, particularly in the backward region. In fact, at 2.11 GeV/c, the Regge-pole prediction agrees better than the polarization predicted by the CERN phase-shift analysis.

In order to study these interesting problems further, we plan to measure polarizations in π^-p elastic scattering, particularly in the back-

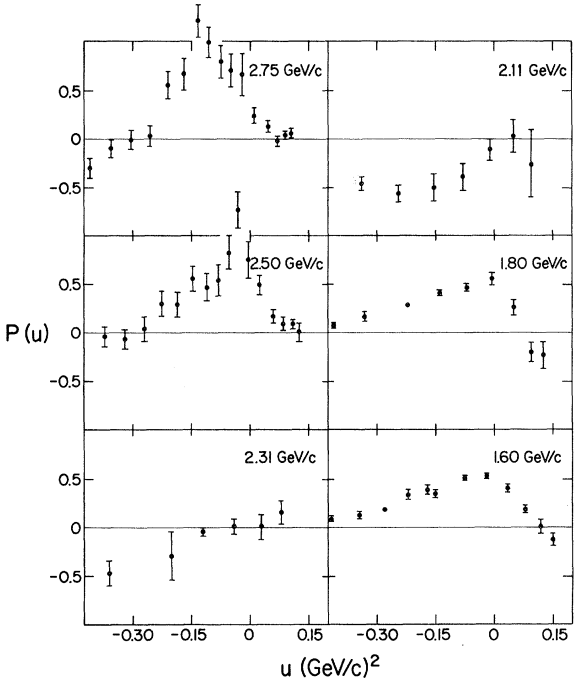

FIG. 2. π^+p polarization as function of $|u|$ for incident momenta of 2.75, 2.50, 2.31, 2.11, 1.80, and 1.60 GeV/c. (The data at 2.75 and 2.50 GeV/c are taken from Ref. 4.)

ward region, in the same energy range.

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γn Partial Cross Sections up to 12 GeV and the Isovector-Isoscalar Interference

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γn reactions are studied in a 40-in. bubble chamber filled with deuterium. Cross sections for channels with no neutral particles in the final state are presented up to a photon energy of 12 GeV. For channels with one neutral particle we present the cross sections at 7.5 GeV only. Comparison of γn reactions with their charge-symmetric γp reactions indicates a considerable isovector-isoscalar interference contribution.

The vector-dominance model (VDM) has been applied successfully to photoproduction interactions. In this model the photon is represented by a combination of a ρ^0 meson (isovector) and an ω and a φ meson (isoscalar). The contribution of the φ meson is believed to be small and therefore often neglected. In some of the calculations using the VDM, the interference between the amplitudes of these mesons is neglected. In some others the interference term is avoided by taking a suitable combination of cross sections so that the term cancels out. A straightforward method to study the magnitude of this interference is a comparison of γn reactions with their γp charge-symmetric ones. This method has already been utilized in the single-pion photoproduction reactions.[1] In this Letter we present results on γn partial cross sections up to 12 GeV which are used for a study of the isovector-isoscalar interference.

The experiment was carried out with the Stanford Linear Accelerator Center (SLAC) annihilation beam[2] in the SLAC 40-in. bubble chamber filled with deuterium. The chamber was exposed to positron-electron annihilation radiation at 7.5 GeV, which was superimposed upon a brems-