

Asymmetry of the photoproduction cross section of positive pions using polarized protons at a photon energy of 340 MeV

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We present the first results of measurement of the asymmetry of the cross section of the reaction $\gamma p \rightarrow n \pi^+$ using a polarized proton target in the region of the first pion-nucleon resonance. The measurements were carried out at a photon energy of 340 MeV for 7 values of the angle of escape of the π^+ meson (30–150°). The obtained results can be used in phenomenological analyses of the processes of single photoproduction of pions by nucleons.

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Until recently, systematic experimental data on the important polarization characteristic of photoproduction of pions-cross section asymmetry on the polarized protons- $T = (d\sigma_{\uparrow} - d\sigma_{\downarrow}) / (d\sigma_{\uparrow} + d\sigma_{\downarrow})$ (where $d\sigma_{\uparrow}$ and $d\sigma_{\downarrow}$ are, respectively, the cross sections of photoproduction of pions by protons polarized normal and antinormal to the reaction plane) in the region of the first pion-nucleon resonance were missing in the literature. In particular, for the $\gamma p \rightarrow n \pi^+$ reaction in the photon energy region E_{γ}

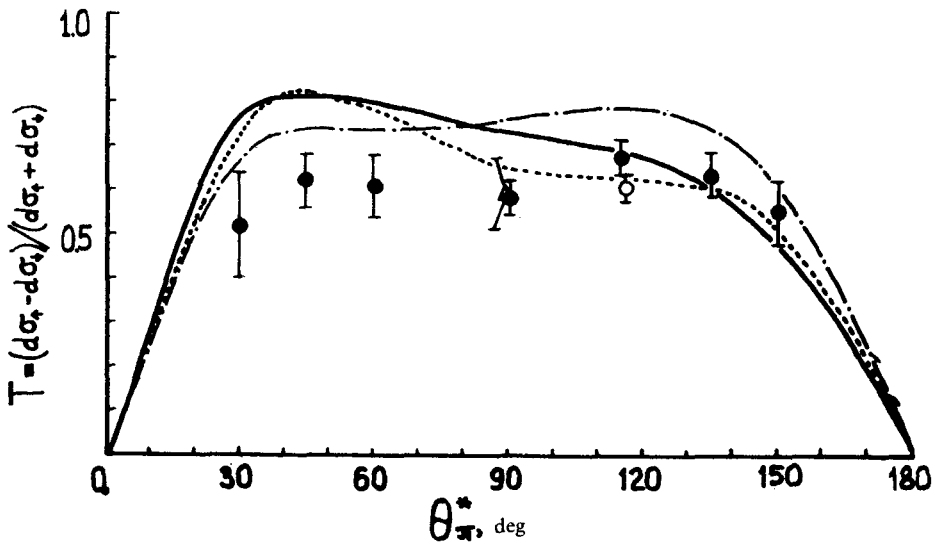


FIG. 1. Angular dependence of the T asymmetry of the cross section of the reaction $\gamma p \rightarrow n \pi^*$ for $E_\gamma = 340$ MeV: \bullet , results of our work; Δ and \circ , data of the Japanese group.^{11,21} The curves give the predictions of the phenomenological analyses (—, Ref. 10; --, Ref. 11; ..., Ref. 12).

< 400 MeV only several values of the T asymmetry were measured¹¹⁻³ and the data on the angular distribution of the observed $T(\theta_\pi^*)$ are missing.

After the polarized proton target was put into operation at the 2-GeV electron linear accelerator of the Khar'kov Physico technical Institute, Ukrainian Academy of Sciences,¹⁴ it became possible to study experimentally the polarized protons observed in the reactions of photoproduction of pions by a proton.

In this paper, we measured for the first time $T(\theta_\pi^*)$ in the reaction $\gamma p \rightarrow n \pi^*$ for the photon energy $E_\gamma = 340$ MeV, for which the energy-independent multiple analyses reveal a maximum instability and irregularity in the behavior of nonresonant amplitudes.¹⁵

The measurements were carried out using a quasi-monochromatic photon beam obtained as a result of coherent bremsstrahlung of 1250-MeV electrons in a 300- μ m-thick diamond single crystal. The production and shaping of the photon beam is described in detail in Ref. 6. The polarization vector of the photon beam was directed at a 45° angle to the reaction plane in order to exclude the effect of polarization of the

TABLE I.

θ_π^* , deg	30	45	60	90	115	135	150
T	0.520	0.623	0.612	0.588	0.680	0.645	0.554
ΔT	0.117	0.065	0.074	0.033	0.042	0.051	0.070

photon beam on the measured pion yields. The T -asymmetry of the cross section measured in this case coincides with the measurements using an unpolarized beam; however, the use of the quasi-monochromatic photon beam significantly decreases the π -meson contribution from the reactions induced by bound nucleons from the nuclei of the working material of the target.

The π^+ mesons were analyzed according to their momentum by magnetic spectrometers^(7,8) and were recorded by the telescopes of the scintillation counters. A threshold Cerenkov counter filled with freon-12 to a pressure of 10 atmospheres was used to separate the positron background.

The polarized proton target, which was described in detail elsewhere,⁽⁴⁾ was redesigned; a proton polarization of $\sim 80\%$ was obtained. An $\text{He}^4 - \text{He}^3$ continuous flow cryostat was used to obtain a temperature of 0.5 K. A 2.7-T magnetic field was produced by the superconducting magnet.⁽⁹⁾ Ethylene glycol $(\text{CH}_2\text{OH})_2$ with the Cr^V complex, which was prepared in the form of 1.5-mm-diam frozen balls placed in a 20×20 -mm³ teflon container, was used as a working material. The polarization of protons of the target was determined from the integral NMR absorption measured by a parallel dc Q -meter. The NMR absorption signal was processed by the M-6000 computer in order to calculate the polarization and to correct for the nonlinearity of the Q -meter. The error in measuring the polarization of the target was $\Delta P/P = 6\%$.

The contribution from the free protons of the polarized target to the measured pion yields was determined by calibration hydrogen measurements, for which the neck (appendix) of the target was filled with liquid hydrogen. A correction for double production of π mesons, which reached a maximum value of $\sim 20\%$ for $Q_\pi^* = 30^\circ$, was introduced into the measured values of the T asymmetry. The obtained results are given in Table I; the errors are statistical.

Figure 1 shows the results obtained by us and the data of Refs. 1 and 2. It also gives the predictions of the phenomenological analyses.⁽¹⁰⁻¹²⁾ It should be noted that only Ref. 12 used experimental data on T asymmetry. All the analyses give a somewhat higher asymmetry for $\theta_\pi^* < 90^\circ$.

The data obtained in this work are of considerable interest from the viewpoint of determining more accurately the values of nonresonance-photoproduction amplitudes.

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