Asymmetry of the cross section of the reaction $\gamma P \to P\pi^0$ in the energy interval 0.9–1.65 GeV at $\theta_{\pi}^{0\,\mathrm{cms}} = 110°$

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(Submitted March 2, 1976)
Pis'ma Zh. Eksp. Teor. Fiz. 23, No. 7, 415–419 (5 April 1976)

We measured the asymmetry of the cross section of the photoproduction of π^0 mesons from hydrogen at 110° in the c.m.s. at linearly polarized photon energies 0.9–1.65 GeV. The results are compared with the existing model predictions in the resonance region.

PACS numbers: 13.60.Kd

To determine the amplitudes of pion photoproduction processes and to compare them with the predictions of various phenomenological models as well as of the quark model,[1,2] various types of polarization investigations are needed besides the measurements of the differential cross sections.

In this paper we present the results of the measurement of the asymmetry of the cross section of the photoproduction of π^0 mesons by polarized photons

$$\gamma + P \to P + \pi^0$$

at an angle $\theta_{\pi^0} = 110°$ in the c.ms. and at photon energies $E_\gamma = 0.9-1.65$ GeV, in steps of 0.15 GeV. There are no analogous experimental data in the literature. These measurements have extended the region of the investigation of the energy behavior of the asymmetry at $\theta_{\pi^0} = 130°$ in the same energy interval.[3]

The experiment was performed with a beam of linearly-polarized photons from a diamond single crystal with electrons of energy 4.6 and 3.6 GeV from

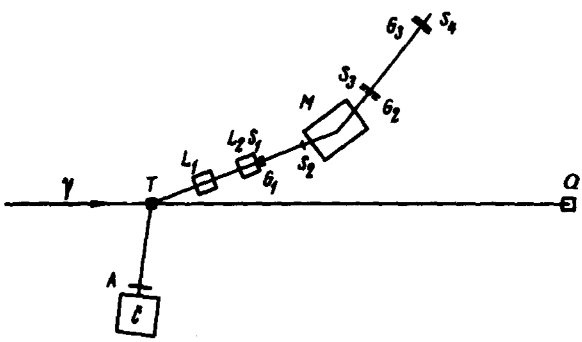


FIG. 1. Experimental setup: L_1 and L_2—magnetic lenses, M—deflecting magne $S_1 - S_4$—trigger counters, $\check{C}$—total-absorption Cerenkov counter, Q—quantameter.

the Erevan synchrotron.[3] The average energy resolution of the photons was $\sigma_{E\gamma} \approx 30$ MeV. The measurements were performed with a liquid-hydrogen target. The recoil protons were registered with a magnetic spectrometer,[4] where the separation of the protons from the π^+ mesons was carried out by time of flight. To separate the two-particle reaction, the magnetic spectrometer was connected for coincidence with a total-absorption Cerenkov counter[5] that registered one photon from the π^0-meson decay (Fig. 1). The contribution of the background processes at a "disturbed" kinematics is estimated at no more than 8%.[3]

The obtained cross section asymmetries

$$\Sigma \equiv \frac{\sigma_\perp - \sigma_\parallel}{\sigma_\perp + \sigma_\parallel} = \frac{1}{P_\gamma} \frac{C_\perp - C_\parallel}{C_\perp + C_\parallel}$$

are listed in Table I. $C_\perp$ and $C_\parallel$ are the numbers of coincidences in the case of photons polarized perpendicular and parallel to the meson production plane, respectively. The errors in the asymmetry include the statistical error in the determination of $C_\perp$ and $C_\parallel$, as well as the error ($\sim 10\%$) in the effective photon polarization ($\overline{P}_\gamma$).

TABLE I.

E_γ, GeV		Σ	
	$\theta_\pi^{cms} = 90°$	$\theta_\pi^{cms} = 110°$	$\theta_\pi^{cms} = 130°$
0.90	...	-0.22 ± 0.07	...
1.05	...	-0.616 ± 0.082	...
1.20	...	-0.44 ± 0.085	...
1.35	...	0.056 ± 0.056	...
1.50	0.52 ± 0.05	0.295 ± 0.063	0.71 ± 0.07
1.65	...	0.48 ± 0.06	...

Using the values of $C_\perp$ and $C_\parallel$, the known acceptance, and the efficiency of the secondary-particle detectors, we calculated the differential cross sections for the unpolarized photons

$$\frac{d\sigma}{d\Omega} = \frac{1}{2}\left(\frac{d\sigma}{d\Omega}\perp + \frac{d\sigma}{d\Omega}\parallel\right).$$

The results are listed in Table II, where the errors are only statistical (we obtained a total systematic error of 15%). Our data on the π^0-meson photoproduction cross sections agree with the previously published measurements of the cross sections with unpolarized photons.[6]

TABLE II.

E_γ, GeV	$(d\sigma/d\Omega)$ ms (μb/sr)
0.90	1.86 ± 0.074
1.05	1.34 ± 0.054
1.20	0.5 ± 0.024
1.35	0.55 ± 0.022
1.50	0.61 ± 0.02
1.65	0.37 ± 0.015

Figure 2 shows the energy dependence of the asymmetry in the energy inter· val 0.9—1.65 GeV at $\theta_{\pi^0} = 110°$ in the c.m.s. The resonances $F_{15}(1690)$, $D_{15}(1670)$ and $F_{37}(1950)$ predominate in this energy region. In the case of the resonance $F_{15}(1690)$ at $E_\gamma = 1.05$ GeV, the quark model predicts a zero asymm try.[1] Just as in the cases $\theta_{\pi^0} = 90°$ [7] and 130° [3] in the c.m.s., our results reveal a structure that requires a strong interference for its explanation. The same figure shows the predictions of Walker's model[1] together with the curv obtained by the Berkeley group.[2,8]

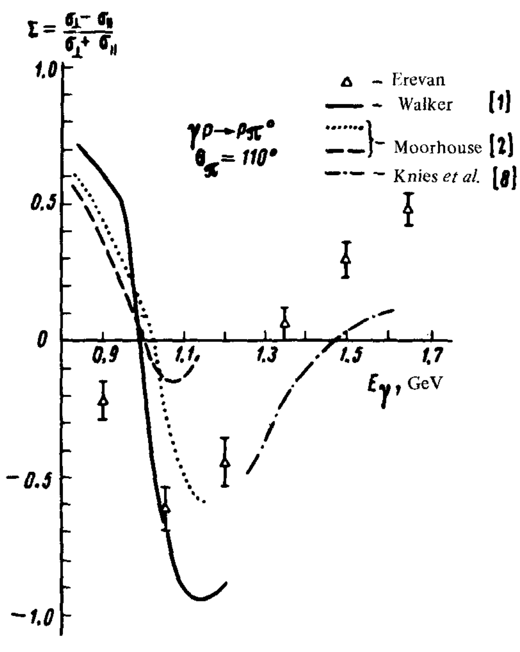
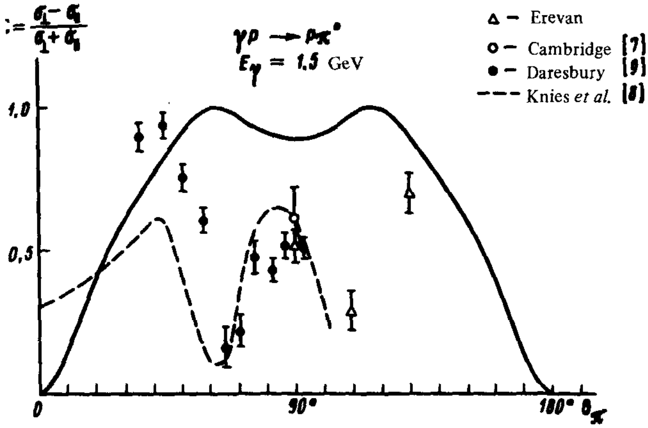


FIG. 2. Energy dependence of the asymmetry of the cross section of the reaction $\gamma P \to P\pi^0$ at $\theta_{\pi^0} = 110°$ in the c.m.s.



IG. 3. Angular dependence of the asymmetry of the cross section of the reac-
on $\gamma P \to P\pi^0$ for $E_\gamma = 1.5$ GeV. The solid curve corresponds to the prediction
the asymmetry Σ in the case of the $F_{37}(1950)$ resonance for pure M_{3+}
agnetic excitation.

Figure 3 shows the angular distribution of the asymmetry at an energy E_γ
1.5 GeV together with the experimental data of[9]. When the photon energy
$_\gamma$ is close to 1.5 GeV, production of resonance $F_{37}(1950)$ is expected. In this
ase the nonrelativistic quark model predicts for the F_{37} resonance a pure M_{3+}
agnetic excitation.[3] Our asymmetry data and the results of[9] do not con-
rm the prediction of the quark model if a pure $F_{37}(1950)$ resonance is excited
: 1.5 GeV.

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