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ANGULAR DISTRIBUTIONS OF THE ASYMMETRY OF THE REACTION $\gamma p \to p\pi^0$ AT γ-QUANTUM ENERGIES 250, 300, AND 350 MeV

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The experimental values of the asymmetry of the cross section can supplement significantly the information needed to carry out a multipole analysis of pion photoproduction reactions, and to ensure a selection of the solutions obtained when such an analysis is carried out. At the present time, there are no experimental data on the angular distributions of the asymmetry of the reaction $\gamma + p \to p + \pi^0$.

We present here the results of measurements of the angular distribution of the asymmetry of the cross sections of the reaction $\gamma p \to p\pi^0$ at γ-quantum energies 250, 300, and 350 MeV. The measurements were performed with a beam of linearly-polarized photons [1, 2] obtained from coherent bremsstrahlung of electrons in single-crystal diamond.

The asymmetry of the cross sections was determined from the experimentally measured quantity R:

$$\Sigma \equiv \frac{\sigma_\perp - \sigma_\parallel}{\sigma_\perp + \sigma_\parallel} = \frac{1}{\bar{P}} \frac{R-1}{R+1}, \qquad (1)$$

where $\sigma_\perp(\sigma_\parallel)$ is the cross section for the production of pions by photons having a polarization vector perpendicular (parallel) to the reaction plane, $R = C_\perp/C_\parallel$

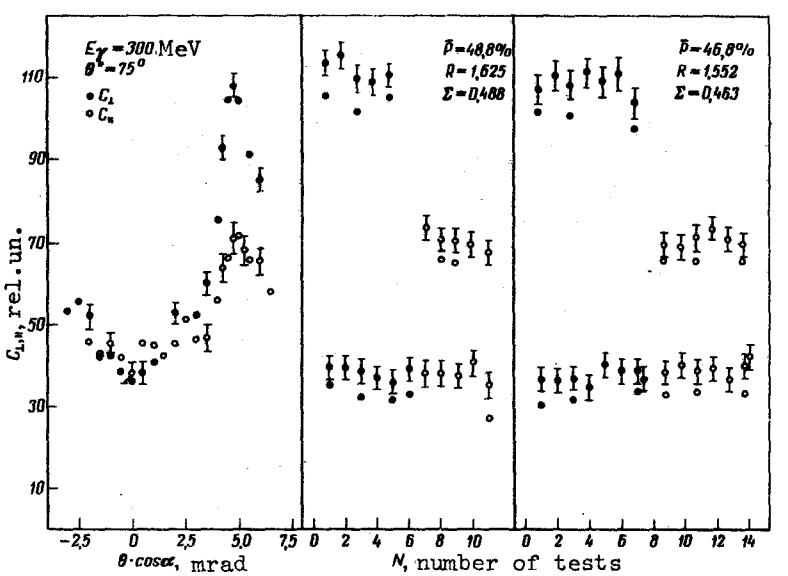

Fig. 1. Photoproton yield from the reaction $\gamma p \to p\pi^0$ vs. the angle of orientation of a single-crystal target. $\theta \sin \alpha$ = 75 mrad.

is the ratio of the proton yields from the photoproduction reaction for the corresponding directions of the photon polarization vector, and $\bar{P}$ is the degree of polarization for the measured spectral photon line.

The quantity $C_{\perp}(C_{\parallel})$ was obtained by measuring the proton yields as functions of the orientation angle of the diamond single crystal, similar to the plots of Fig. 1.

The protons were magnetically analyzed and registered with a scintillation-counter telescope, with separation from the background particles by the dE/dx method.

The angle and energy ranges of the magnetic spectrometer ensured a primary-photon energy resolution 7 - 10%.

Numerous changes of the crystal orientation between angles corresponding to the maximum and minimum intensity of the spectral photon line for two polarization-vector directions made it possible to measure the quantities $C_{\perp}(C_{\parallel})$ and C_0, respectively, as well as the value of the coherent effect:

$$U = \frac{C_{\perp} + C_{\parallel}}{2C_0}. \qquad (2)$$

A theoretical analysis of the connection between the value of the coherent effect determined from the reaction-product yield and the intensity and polarization of the spectral photon line, averaged over the energy resolution of the apparatus, with additional allowance for the incoherent contribution made to the photoproton yield by the background reactions, has shown that the measured quantity U is uniquely related with the effective polarization $\bar{P}$:

$$\bar{P} = \frac{2(1-x)}{1+(1-x)^2}\,\frac{U-1}{U}, \qquad (3)$$

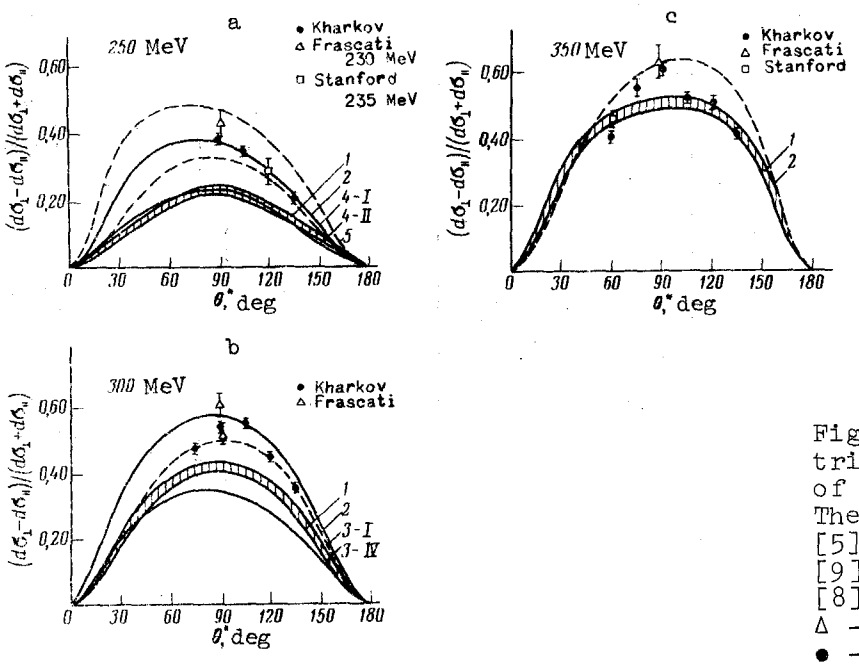

Fig. 2. a - c) Angular distributions of the asymmetry of the reaction $\gamma p \to p\pi^0$. Theoretical curves: 1 - from [5], 2 - from [6], 3 - from [9], 4 - from [7], 5 - from [8]. Experimental results: Δ - from [3], □ - from [4], • - present work.

where $x = E_\gamma/E_0$ is the relative energy of the spectral line and E_0 is the energy of the primary electron.

An estimate of the background, which is due mainly to the reaction $\gamma p \to \pi^- N^{*++} \to \pi^-\pi^+ p$ has shown that it is coherent at the investigated energies, i.e., it does not depend on the crystal orientation angle, and formula (3) is valid.

The table lists the asymmetry measurement results obtained at the upper energy of the photon spectrum 1150 MeV.

E_γ	θ^*, deg	R	$\bar{P}$, %	Σ
250	90	1,471	49,3	0,387 ± 0,018
	105	1,419	49,5	0,350 ± 0,016
	135	1,224	47,8	0,210 ± 0,017
300	75	1,588	47,8	0,475 ± 0,015
	90	1,686	47,3	0,541 ± 0,018
	105	1,718	47,8	0,553 ± 0,016
	120	1,546	47,4	0,452 ± 0,014
	135	1,352	42,0	0,357 ± 0,015
350	60	1,403	38,6	0,434 ± 0,031
	75	1,603	41,7	0,555 ± 0,025
	90	1,770	45,5	0,611 ± 0,021
	105	1,582	41,5	0,543 ± 0,022
	120	1,480	37,5	0,516 ± 0,024
	135	1,330	34,4	0,412 ± 0,030

The errors in the asymmetry include the statistical error in the determination of $C_\perp$ and $C_\parallel$, and also the polarization error $\Delta P \approx 1\%$.

The results are compared with the experimental data from other laboratories [3, 4] and with predictions of the dispersion theory [5] and of certain multipole analyses [6 - 9].

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