Measurement of longitudinal component of proton polarization in the reaction $\gamma+p\to\pi^0+p$ on linearly-polarized photons

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Preliminary results are reported of the measurement of proton polarization in the reaction $\gamma+p\to\pi^0+p$ on a linearly polarized beam of photons with a polarization vector inclined 45° (135°) to the reaction plane. The longitudinal component of the polarization vector (P_z) is obtained. The experimental results are compared with the Schwela dispersion analysis and with the Walker phenomenological analysis.

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Investigations of the polarization of secondary nucleons using linearly-polarized photon beams greatly extend the possibilities of studying the photoproduction of pions on nucleons, since they permit measurements of new experimentally observed quantities.[1] Of particular interest are experiments in which the photon-beam polarization vector makes an angle $\phi=45°$ (135°) with the reaction plane, in view of the possibility of measuring the three components of the polarization vector:

$$P_x=\pm\frac{\mathrm{Im}H_3^{(-)}}{A^{(+)}};\quad P_y=\frac{\mathrm{Im}H_1^{(+)}}{A^{(+)}};\quad P_z=\frac{\mathrm{Im}H_2^{(-)}}{A^{(+)}};$$

where $H_1^{(+)}$, $H_2^{(-)}$, $H_3^{(-)}$, and $A^{(+)}$ are corresponding bilinear combinations of the helicity amplitudes[2]; the signs "+" and "−" in the expressions for P_x and P_z pertain to the angles $\phi=45°$ and $\phi=135°$, respectively. In experiments on polarized photons one determines only the P_y component of the polarization vector.

In this study we performed, for the first time, measurements of the longitudinal component of the polarization vector of the protons in the reaction $\gamma+p\to\pi^0+p$ on linearly polarized photons of energy 495 MeV with a polarization vector directed at an angle 45° (135°) to the reaction plane. The measurements were performed at a pion emission angle 105° in the c. m. s.

The linearly polarized photon beam was obtained from coherent bremsstrahlung of electrons from the Khar'kov 2-GeV linear accelerater in a diamond single crystal.[3] The experiment was performed with two magnetic spectrometers. The polarization of the protons was measured with a telescope of optical spark chambers[4] installed at the exit of one of the magnetic spectrometers. A telescope of scintillation counters at the exit from the second spectrometer made it possible to monitor the stability of the polarization of the photon beam during the experiment against the proton yields from the investigated reaction.

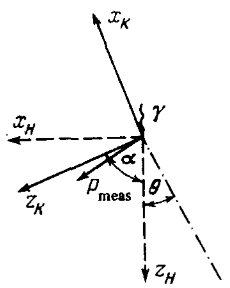

FIG. 1. Coordinate system in which the components of the polarization vector in the reaction plane were measurements: X_H and Z_H are the directions of the P_x and P_z components prior to passing through the magnetic spectrometer; X_k and Z_k are the directions of P_x and P_z components after passing through the magnetic spectrometer: θ is the angle of registration of the secondary protons (34.5°).

Three independent measurements were made in the experiment: with the polarization vector at an angle $\phi=45°$ or $\phi=135°$ and in the absence of the coherent effect. The second measurement was made to exclude a possible false asymmetry, and the last was made to take the incoherent background into account.

In investigations of the P_x and P_z components of the polarization vectors it is necessary to take into account the precession of the proton spin in the magnetic field of the spectrometer. The precession angle α is determined from the relation[5]

$$\alpha=E/m(g/2-1)b\ ,$$

where E and m are the total energy and the mass of the proton; g is equal to 2.793 for protons, and b is the angle of rotation of the spectrometer (30°). Figure 1 shows the coordinate system in which the polarization P_{meas}, determined by the components P_x and P_z, is measured:

$$P_{meas}=P_x\cos(\alpha+\theta)+P_z\sin(\alpha+\theta)=-0.12P_x+0.99P_z\ .$$

At the given kinematics of the proton polarization measurements, the main contribution to P_{meas} is made by the P_z component.

The table shows our present results. The P_z component was calculated from P_{meas}, and the value P_x

E_γ, MeV	θp lab	α	P_{meas}	P_y	P_z
495	34.5°	62.3°	− 0.47 ± 0.27	− 0.20 ± 0.27	− 0.54 ± 0.28

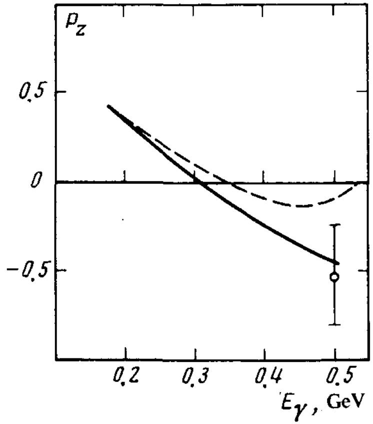

FIG. 2. Energy dependence of the longitudinal component of the polarization vector. Solid curve—results of Schwela's dispersion analysis[6]; dashed—results of Walker's phenomenological analysis.[7] The circle and error bar represent our present results.

= 0.11 was taken from Schwela's analysis,[6] which is based on the dispersion relations. Figure 2 shows a comparison of the obtained value of P_z with the predictions of the Schwela dispersion analysis and the Walker phenomenological analysis.[7]

It should be noted that although our measurements of the P_z components are preliminary, the experimental value favors the predictions of the dispersion theory. However, for more definite conclusions concerning the applicability of any particular theoretical model we must have measurements in a wide range of pion emission angles and photon energies.

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