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PHOTOPRODUCTION OF NEUTRAL π MESONS FROM PROTONS AT 210 MeV

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Differential cross sections for the $\gamma + p \rightarrow p + \pi^0$ process have been measured at six angles for a photon energy $E_{\gamma\text{lab}} = 210 \pm 14$ MeV. Results of the measurements are compared with the cross sections calculated on the basis of dispersion relations.

1. A complete phase-shift analysis for the photoproduction of mesons from nucleons requires detailed measurements of the differential cross sections for these processes. Such measurements can also give information on the applicability of dispersion theory for description of the experimental data and on the role of the π-π resonance interactions in these processes, in particular on the $\gamma\pi\rho$ coupling constant Λ which enters into a number of effects.[1] From this point of view it is of interest to study the processes $\gamma + N \rightarrow N + \pi$ in the photon energy region near threshold where the uncertainties in the theoretical calculations of the photoproduction amplitudes are minimal. As Govorkov and Lebedev have shown in their analysis[2] using the bipion model,[3] the differential cross section for photoproduction of π mesons from protons at large angles is sensitive to the value of Λ.

The purpose of the present article is to report measurements of the differential cross section for $\gamma + p \rightarrow p + \pi^0$ at a primary photon energy $E_{\gamma\text{lab}} = 210 \pm 14$ MeV and to discuss these results on the basis of dispersion theory.

2. The investigations were carried out in the bremsstrahlung beam of the FIAN 265-MeV synchrotron. The π^0 mesons were observed by counting the two π^0-decay γ rays in coincidence. The apparatus used has been described by us previously.[4] In contrast to the previous work,[4] in the present case we used as a liquid hydrogen target an ordinary glass Dewar with a wall thickness of 1 mm. The diameter of the internal vessel of the Dewar was 14 cm and the external vessel, 16 cm. The axis of the Dewar was perpendicular to the bremsstrahlung beam. The hydrogen capacity of the Dewar was 4 liters, which allowed us to make continuous measurements for a period of 12 hours.

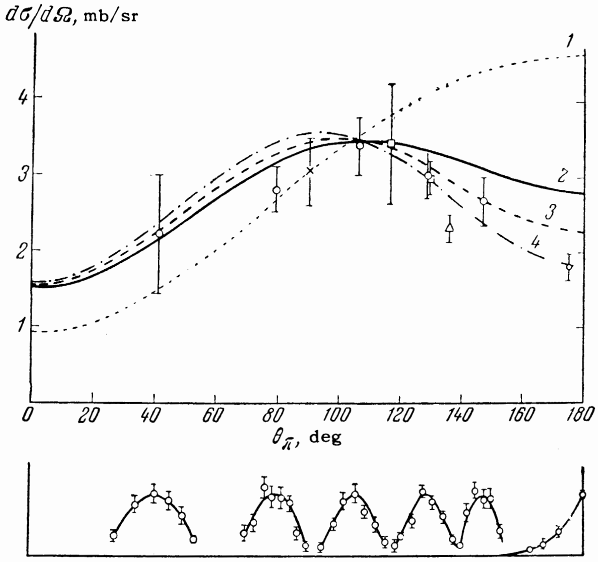
The small lateral dimensions of this target made possible effective collimation of the π^0-decay photons counted. The location of the secondary collimators was such that the γ-ray telescope did not "see" the entrance and exit walls of the target. The empty-target background for π^0 mesons emitted at 30° (lab) to the bremsstrahlung beam was ~50% of the γ-γ coincidence counting rate from the target with hydrogen. For larger angles (60° and larger) the empty-target background was ~5% of the net counting rate. The technique of the measurements was the same as previously described.[4]

3. The number of γ-γ coincidences per unit primary photon flux was measured for six different meson angles θ. Using the method described by Govorkov et al.,[5] we determined from the measured yields the differential cross sections for photoproduction of π^0 mesons from protons, which are shown in the figure.

Calculation of the energy resolution of the apparatus for different values of θ showed that the smearing in energy was the same for all angles and amounted to ± 14 MeV. The mean energy for the different angles varied over a range of 6 MeV. For reduction of the data measured at different angles to a mean energy of 210 ± 14 MeV, we made an extrapolation using the differential cross section energy dependence determined in experiments in which one π^0-decay photon was counted.[6]

Data of other authors[7-9] are also shown in the figure for comparison. The points from the work of Miller and Bellamy[8] and Bernardini et al.[9] at energies close to 210 MeV were plotted on the graph by means of the extrapolation described above. It can be seen from the figure that in the region of overlap there is good agreement of the entire set of data.

4. Since there are a number of major inaccu-



Differential cross section for the reaction $\gamma + p \to p + \pi^0$ for $E_{\gamma \mathrm{lab}} = 210$ MeV. θ_γ is the π^0-meson angle in the c.m.s. Below are plotted the relative angular resolutions of the apparatus, calculated by the Monte Carlo method. The triangles are the data of Koester and Mills, [7] the crosses are the data of Miller and Bellamy, [8] the squares are the data of Bernardini et al., [9] and the circles are our results. Curves 2, 3, and 4 are calculated for values of the $\gamma\pi\rho$ coupling constant Λ/ef of 0, 0.5, and 1. Curve 1 is obtained by taking into account only the first resonance in the imaginary part of the photoproduction amplitude.

racies in the most systematic calculations[10] of the amplitude and cross sections of the meson photoproduction processes based on one-dimensional dispersion relations,[11] we carried out new calculations of the differential cross sections of the process studied. In the calculation of the dispersion integrals we took into account the contributions of the first and second pion-nucleon resonances, and also the contribution of pion photoproduction in the nonresonant S- and P-states. The imaginary parts of the resonance amplitudes were determined from experimental data on the processes $\gamma + p \to p + \pi^0$ and $\pi^+ + p \to p + \pi^+$.[4,12,13] The imaginary parts of the nonresonant amplitudes were calculated on the basis of static dispersion relations with correction for nucleon recoil, using the results of Hamilton and Woolcock[14] for description of the π-N scattering phase shifts.

The greatest part of the uncertainty in the theoretical calculations is connected with the contribution to the dispersion integrals of the nonresonant amplitudes, which affects mainly the formation of π^0 mesons in S-states.

The results of the calculations are also shown in the figure. Curve 1, calculated by taking into account in the imaginary parts of the amplitudes only the first resonance, does not agree with the experimental data. Consideration of the contributions of the second resonance and of the nonresonant amplitudes (curve 2) leads to a significant reduction in the disagreement with the experimental results. If the remaining discrepancies at large angles are assigned to the ρ-meson contribution to the photoproduction amplitude, we obtain for the $\gamma\pi\rho$ coupling constant the value $\Lambda = (0.5 \pm 0.5)$ ef. Thus, the data presented can be described within the framework of the bipion model without introduction of a subtraction constant in the $\gamma + \pi \to \pi + \pi \to N + \tilde{N}$ channel.

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[1] L. D. Solov'ev and Ch'en Ts'ung-mo, JETP **42**, 526 (1962), Soviet Phys. JETP **15**, 369 (1962). M. Kawaguchi and H. Yokomi, Suppl. Progr. Theor. Phys. **21**, 71 (1962).

[2] B. B. Govorkov and A. I. Lebedev, FIAN preprint, A-48, 1963.

[3] Gourdin, Lurie, and Martin, Nuovo cimento **18**, 933 (1960). De Tollis, Ferrari, and Munczek, Nuovo cimento **18**, 198 (1960).

[4] Govorkov, Denisov, Lebedev, and Minarik, JETP **44**, 1463 (1963), Soviet Phys. JETP **17**, 983 (1963).

[5] Govorkov, Denisov, and Minarik, JETP **44**, 878 (1963), Soviet Phys. JETP **17**, 598 (1963).

[6] Vasil'kov, Govorkov, and Gol'danskiĭ, JETP **37**, 11 (1959), Soviet Phys. JETP **10**, 7 (1960).

[7] L. Koester and F. Mills, Phys. Rev. **105**, 1900 (1957).

[8] D. B. Miller and E. H. Bellamy, Proc. Intern. Conf. on High Energy Phys., Geneva, 1962.

[9] Bernardini, Hanson, Odian, Yamagata, Auerbach, and Filosofo, Nuovo cimento **18**, 1203 (1960).

[10] J. S. Ball, Phys. Rev. **124**, 2014 (1961).

[11] Logunov, Tavkhelidze, and Solovyov, Nucl. Phys. **4**, 427 (1957). Chew, Goldberger, Low, and Nambu, Phys. Rev. **106**, 1345 (1957).

[12] K. Berkelman and J. A. Waggoner, Phys. Rev. **117**, 1364 (1960).

[13] Klepikov, Sokolov, and Meshcheryakov, JINR preprint D-584, 1960.

[14] J. Hamilton and W. S. Woolcock, Rev. Mod. Phys. **35**, 737 (1963).

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