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ЦЕНТРАЛЬНЫЙ НАУЧНО-ИССЛЕДОВАТЕЛЬСКИЙ ИНСТИТУТ
ИНФОРМАЦИИ И ТЕХНИКО-ЭКОНОМИЧЕСКИХ ИССЛЕДОВАНИЙ
ПО АТОМНОЙ НАУКЕ И ТЕХНИКЕ
ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ

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TOTAL CROSS SECTION OF HADRON PHOTOPRODUCTION ON Be, C, H_2O AND Al NUCLEI IN THE ENERGY RANGE E_γ = (200-900) MEV

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New experimental results of the measurement of total cross section of hadron photoproduction on Be, C, H_2O and Al nuclei for the photon energy of 0.2-0.9) GeV obtained on the tagged photon beam by means of hadron detectors covering the solid angle ~ 4π are reported. The results are compared with the available data on total cross section of hadron photoproduction. For the oxygen nucleus the comparison is carried out with the theoretical predictions for the photon energy up to 400 MeV.

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ПОЛНОЕ СЕЧЕНИЕ ФОТООБРАЗОВАНИЯ АДРОНОВ НА ЯДРАХ Be , C , H_2O и Al В ОБЛАСТИ ЭНЕРГИИ E_γ =(200-900) МЭВ

Приводятся новые экспериментальные результаты измерения полного сечения фотообразования адронов на ядрах Be, C , H_2O и Al для энергии фотонов (0,2-0,9) ГэВ, полученные на меченом фотонном пучке с использованием адронных детекторов, перекрывающих телесный угол ~ 4π. Результаты сравниваются с имеющимися в настоящее время данными по полному сечению фотообразования адронов. Для ядра кислорода приводится также сравнение с теоретическими предсказаниями для энергии фотонов до 400 МэВ.

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1. Introduction

The study of the process of hadron photoproduction on nuclei in the nucleon resonance energy range is at present a subject of intensive experimental and theoretical research. Accumulation of data in this energy region allows one to apply the sum rule [1] as well as to define more precisely the information on static characteristics of nuclei [2]. Of great interest are the data on total cross sections of hadron photoproduction on nuclei in the Δ (3.3) resonance energy region where the theoretical predictions are available [3,4].

The values of total cross section of photoabsorption on Li and Be nuclei in the energy range up to 350 MeV are obtained at Mainz [5] by the beam attenuation method on H, D, He, C, Al, Ni, Mo, W nuclei, in the energy range up to 500 MeV are obtained at Kharkov [6] in the electroproduction experiment at small transferred momenta [7].

Total cross section of hadron photoproduction by the tagged photon method is measured on H [8] and D [9] in the photon energy range of (0.18-2.0) GeV and (0.26-4.2) GeV, respectively; the cross section of charged hadron photoproduction, also on the tagged photon beam - on He, Be, C, O, Al, Ti, Cu, Sn, Pb nuclei in the energy range of (0.2-0.39) GeV is measured

at Bonn [10] , and on carbon - at Tomsk [11] . Available is also the measurement of photoabsorption cross section on the lead nucleus, performed on the quasi-monochromatic γ-quanta beam from positron annihilation in flight by means of detection of photoneutrons in the Δ (3.3) energy region [12] .

We have performed and described in Ref. 13 the measurement of total cross section of hadron photoproduction on Be, C, O, Cu nuclei in the tagged photon energy range of (0.25-2.7) GeV. In the present report we give new results of the measurement of total cross section of hadron photoproduction on Be, C, H_2O, Al nuclei in the tagged photon energy range of (0.2-0.9) GeV. The results are compared with the analogous cross sections available and with the theoretical predictions.

2. Experiment

The measurements were carried out on the tagged photon beam. The secondary electron beam of $\sim 4\ 10^5$ e^-/sec formed by us on the basis of the extracted electron beam of the Yerevan Physics Institute accelerator [14] , on the lead radiator of 0.01 rad. units thickness, produced a photon beam of $\sim 5\ 10^3$ photons per second intensity in the energy range E_γ =(0.2-0.9) GeV .

The experimental setup (Fig.1) as well as the experimental technique were described in Ref. 13 . The photons of definite energy registered by the coincidence of signals from the tagging system counters and from the shower detector produced hadrons in the target surrounded by the 4π -detector. The charged hadrons and γ-quanta from the π^0-meson decay were registered by that detector, whereas the non-interacted with target γ-quanta and the main part of electron-positron pairs produced in the target passed through the hole and were excluded when falling upon the shower detector

which operated in anticoincidence with the hadron detector.

The portion of false events due to the registration by the hadron detector of one particle of the electron-positron pair, when the other particle wasn't registered by the shower detector because of its inefficiency, was determined by control measurements. Also the level of random coincidences was regularly measured. The background measurements in the absence of the target were taken.

While analysing the measurement results, besides the corrections described in Ref. 13 , also the additional factors were considered, which affected the determination of total cross section of hadron photoproduction. The contribution to the total cross section of events of registration by the hadron detector of both particles of the electron-positron pair was determined by the Monte-Carlo calculations. The calculations performed with account of the angular distribution and multiple scattering of the electron-positron pairs produced in the target have shown that for the photon energy up to 350 MeV such contribution is rather perceptible, it depends on the target thickness and decreases with increasing the tagged photon energy.

The number of the low-energy hadrons whose mean range was less than the hadron detector thickness was determined with respect to the kinematics of the hadron production on quasi-free nucleons. It turned out that the correction due to the registration threshold of the hadron detector also had strong energy dependence, it decreased with increasing energy and made 2.5% for the photon energy E_γ = 300 MeV.

3. The Measurement Results

Our obtained total cross section of hadron photoproduction on Be, C, H_2O, Al nuclei of (0.05-0.15) rad. units thickness in the energy region

E_γ = (0.2-0.9) GeV is presented in the table. Fig.2 shows the energy dependence of our obtained cross section for carbon together with the data of Kharkov [6], Bonn [10] and our earlier results [13]. Note, that the total cross section of hadron photoproduction at Bonn was obtained by measuring the total cross section of charged hadrons and adding to it the cross section of neutral hadrons calculated by the Monte-Carlo method. The solid curve corresponds to the sum of photonucleon cross sections averaged over nucleon momentum distribution in nucleus. Our obtained cross sections are closer to the Bonn results, being less than the sum of photonucleon cross sections in the photon energy range up to 500 MeV. Some decrease in the values presented by us, as compared with our earlier results [13], is due to the account in the present work of the large-angle electron-positron pairs simulating the false case of hadron photoproduction.

Fig.3 shows the total cross section of hadron photoproduction on oxygen obtained from the data on H_2O together with the Bonn results and theoretical predictions in the framework of isobar-hole formalism [3], isobar doorway model [4] and impulse approximation. In the $\Delta(3.3)$ resonance region our cross sections are lower than the impulse approximation prediction and agree satisfactorily with the isobar-hole formalism prediction.

The authors are indebted to A.Ts.Amatuni and H.H.Vartapetyan for their interest in the work, to A.I.Akopyan, V.M.Aslanyan, K.T.Darbinyan, A.O.Kechechyan, E.M.Oganesyan, S.G.Simonyan and Sh.K.Shiroyan for their assistance in the work, and also to the accelerator staff for providing with the beam.

TABLE

Total cross section of hadron photoproduction

E_γ MeV / target	230 ±42	292 ±47	375 ±52	430 ±70	472 ±58	500 ±40	591 ±35	634 ±51	650 ±39	772 ±45	800 ±45	845 ±45	877 ±50
Berillium	2.02 ±0.12	3.33 ±0.2	3.27 ±0.16	1.96 ±0.09	1.24 ±0.09	1.65 ±0.1	1.7 ±0.12	1.7 ±0.14	1.45 ±0.13	2.06 ±0.15	1.47 ±0.12	1.49 ±0.13	1.58 ±0.15
Carbon	3.82 ±0.17	4.18 ±0.45	4.28 ±0.33	3.26 ±0.12	2.67 ±0.1	3.37 ±0.12	2.53 ±0.14	2.2 ±0.11	2.24 ±0.15	1.86 ±0.13	2.28 ±0.15	2.13 ±0.15	2.15 ±0.17
H_2O	-	5.64 ±0.5	7.51 ±0.4	4.62 ±0.4	3.01 ±0.5	3.76 ±0.3	4.02 ±0.4	3.17 ±0.3	3.4 ±0.4	3.48 ±0.34	3.84 ±0.4	4.18 ±0.3	3.13 ±0.5
Oxygen	-	4.78 ±0.3	6.71 ±0.36	4.14 ±0.38	2.65 ±0.46	3.38 ±0.25	3.6 ±0.25	2.71 ±0.25	2.88 ±0.3	2.93 ±0.3	3.32 ±0.3	3.7 ±0.3	2.7 ±0.4
Aluminium	7.68 ±1.2	6.00 ±0.8	11.76 ±3.2	6.38 ±0.9	4.38 ±0.8	3.92 ±0.7	5.78 ±0.8	6.84 ±0.9	5.9 ±1.1	6.84 ±1.2	4.34 ±0.9	4.48 ±0.8	7.44 ±1.3

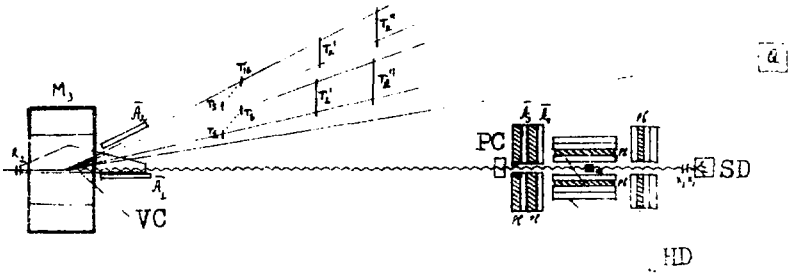

Fig.1. A general diagram of the experimental setup.

R_2 - radiator, M_3 - analysing magnet,

VC - vacuum chamber, $\bar{A}_1$ - $\bar{A}_4$ - veto counters,

T_1 - T_{16}, $T'_{1,2}$, $T''_{1,2}$ - tagging system counters,

Q - quantometer, PC - multiwire proportional chamber, HD -hadron detector, m - target, Pb - lead converter, X_1, X_2 - scintillation counters, SD - shower detector.

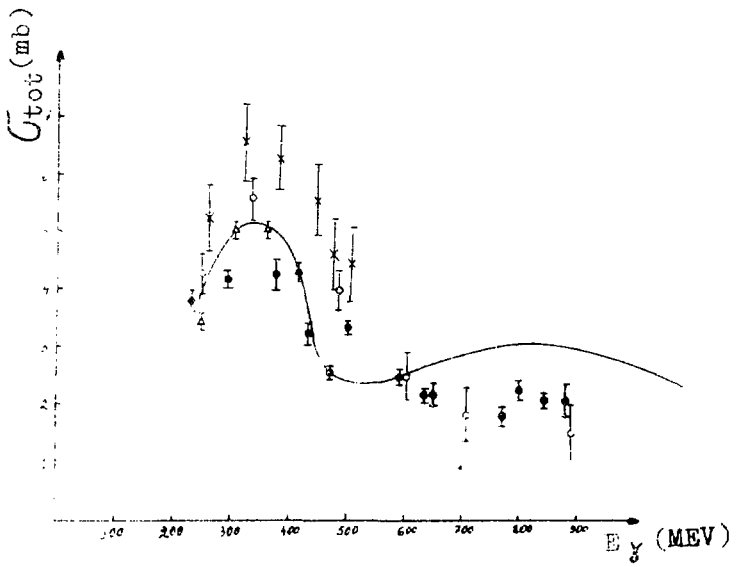

Fig.2. Energy dependence of total cross section of hadron photoproduction on carbon.

● - our results, ○ - Yerevan-83 [13],

× - Kharkov [6] , Δ - Bonn [10] .

Curve - the sum of photonucleon cross sections [6] .

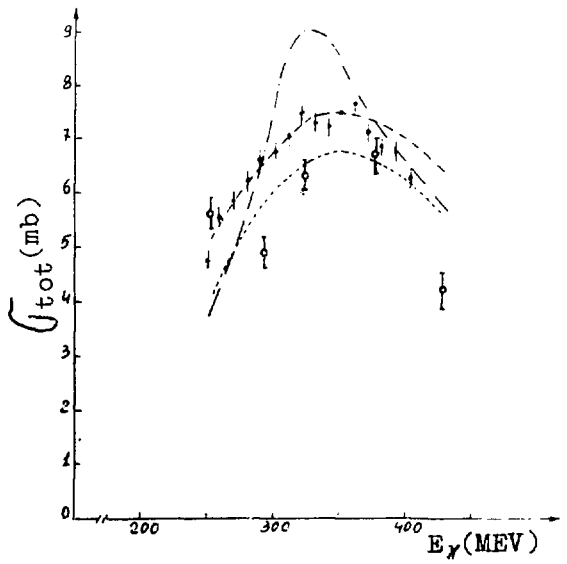

Fig.3. Energy dependence of total cross section of hadron photoproduction on oxygen.

o -our results, ● - Bonn [10] .

Curves: dash-dotted - plane wave impulse approximation, dashed - isobar doorway model [4] , dotted - isobar-hole formalism [3] .

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