REFINEMENT OF THE EXPERIMENTAL VALUES OF THE COMPTON-EFFECT CROSS SECTIONS FOR THE PROTON

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The values of the differential cross sections for the Compton effect on the proton are given for γ-quantum energies from ~230 to ~250 MeV. These values of the cross sections are the result of a more accurate analysis and of making absolute the experimental data obtained by us earlier.[1]

OUR experimental results on the angular dependence of the Compton-effect cross section for the proton at an average γ-quantum energy of 247 MeV were published earlier[1] (cited henceforth as I).

The Compton-effect cross sections were made absolute using the published value of the cross section for the photoproduction of π^0-mesons on hydrogen $(d\sigma/d\Omega)_{\text{l.s.}} = 26.6 \pm 2.7\,\mu\text{b/sr}$, calculated from the results of Koester and Mills[2] for the γ-quantum energy $E = 247$ MeV and the angle of emission of the recoil protons $\theta_p = 16°$ in the laboratory system (l.s.). More accurate measurements of the π^0-meson photoproduction cross section, carried out in our laboratory,[3] showed that the cross section that we used was about 20% too low.

In the investigation of the Compton effect by recording the coincidences between the scattered γ quanta and the recoil protons, the procedure in the calculation of the differential cross sections from the measured yields is quite complicated and requires an allowance for the dependence of the number of "effective" target nuclei and of the number of γ quanta on the energy and angle of emission of particles within the limits of the angular range covered by detectors. The effects of the multiple scattering of protons in the filters of the proton telescope also play an important role. The characteristic feature of the investigation of the Compton effect at energies above the π-meson photoproduction threshold is that the range of the effective γ quanta lies at the limit of the bremsstrahlung radiation. The aforementioned dependences are very strong and the calculations of the cross sections from the measured yields become very time-consuming. A sufficiently accurate allowance for all the factors is possible only if electronic computers are used.

The results of the investigation I were analyzed without the use of electronic computers, some approximations being made in the calculation of the instrument function. Moreover, in I we used the range–energy relationship for protons in hydrogen given in [4]. It was later found[5] that the values of the range were about 5% too high. In view of this, it was decided to refine the analysis of the results given in I. Such a refinement is particularly desirable because there are as yet no other experimental data, except those given in I, on the angular dependence of the Compton-effect cross section for the proton at energies higher than the meson photoproduction threshold.

A fresh analysis of the yields obtained in I was carried out using an electronic computer which made it possible to eliminate some of the approximations in the original analysis. The results given in [5] were used in the range–energy relationship. The cross sections were made absolute, as in I, using the published value of the cross section for the neutral π-meson photoproduction: we used the value $d\sigma/d\Omega = 32.6 \times 10^{-30}\ \text{cm}^2/\text{sr}$ in the laboratory system of coordinates.

The values of the differential cross section for the elastic scattering of γ quanta by protons, obtained in this way, are listed in the table. These refined absolute values were approximately 20–30% higher than those given in I. This had practically no effect on the angular distribution.

For convenience in analysis of the experimental data, we approximated the resultant angular dependence of the cross section by a formula of the type

$$\frac{d\sigma}{d\Omega}(\theta_\gamma)_{E_\gamma=248} = a_0 + a_1 \cos\theta_\gamma + a_2 \cos^2\theta_\gamma.$$

We used only the experimental results obtained at

$\bar{\theta}_p$ (l.s.), deg	$\bar{\theta}_\gamma \pm \Delta\theta_\gamma$ (c.m.s.)	$\bar{E}_\gamma \pm \Delta E_\gamma$ (l.s.)	$d\sigma/d\Omega \pm \Delta$ (c. m.s.) 10^{-32} cm^2/sr	δ, %
16	147.5±1.1	248.1± 4.4	12.79±1.07	8.4
24	131.8±1.2	248.3± 4.3	9.13±0.78	8.5
36	108.4±1.1	248.0± 4.9	9.56±1.02	10.7
44	92.6±1.1	247.4± 5.3	6.05±0.70	11.5
56	69.5±1.3	239.5± 9.8	6.08±0.76	12.5
64	55.4±1.4	235.0±12.7	4.24±0.57	13.5

one and the same γ-quantum energy of ~248 MeV (protons were recorded at the angles of 16, 24, 36, and 44° in the laboratory system) and the value of the differential cross section for the emission of the scattered γ quanta at the angle $\theta_\gamma = 0°$, $(d\sigma/d\Omega)_{\theta\gamma=0} = (6.8 \pm 0.68) \times 10^{-32}$ cm^2/sr, which was the average of the results of several theoretical calculations[6] (the scatter of the theoretical values of the cross sections for this point did not exceed 10%).

The values of the parameters a_i were (in units of 10^{-32} cm^2/sr)

$$a_0 = 6.33 \pm 0.63, \quad a_1 = -3.25 \pm 0.66,$$
$$a_2 = 3.71 \pm 1.10.$$

The total cross section for the Compton effect at the energy of 248 MeV, calculated from these parameters a_i, was found to be

$$\sigma_{\text{tot}} = (95.0 \pm 9.3) \cdot 10^{-32} \text{ cm}^2.$$

In 1964, we carried out new measurements of the angular dependence of the differential cross section of the Compton effect for two γ-quantum energies. These measurements are now being analyzed.

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