CHARGE EXCHANGE SCATTERING OF 240 – 330 Mev π^- MESONS ON HYDROGEN

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The results are given of the measurement of the differential cross sections of charge-exchange scattering of 240, 270, 307, and 333-Mev π^- mesons on hydrogen.

1. EXPERIMENTAL ARRANGEMENT

THE angular distribution of π^0 mesons was determined from the angular distribution of the γ quanta produced in the decay of these mesons.

The geometry of the experiment is shown in Fig. 1. A detailed description of the apparatus employed and the liquid hydrogen target was given in reference 1. The γ quanta were detected by means of a telescope consisting of scintillation counters 3, 4, and 6. To increase the efficiency of registration of the γ quanta by counter 3, we used a lead plate 7.4 g/cm^2 thick, in which these quanta were converted into electron—positron pairs.

Counters 1, 2, 3, and 4 were connected in anticoincidence with counter 6, so that the charged mesons falling in the telescope were not recorded. At the same time, the efficiency of registration of γ quanta decreased only slightly ($\sim 1\%$) by conversion in counter 6, which was a Plexiglas container $16 \times 17 \times 1.5$ cm filled with a solution of terphenyl in phenyl cyclohexane (3 g/l). The efficiency of operation of the anticoincidence circuit was continually checked. This could be done because 12346 coincidences were registered side by side with $1234\overline{6}$ anticoincidences. The sum of these coincidences and anticoincidences should be exactly equal to the number of 1234 coincidences.

2. EFFICIENCY OF REGISTRATION OF γ QUANTA

In determining the efficiency of registration of the γ quanta, we made use of a method similar to that used by Anderson et al.[2]

It can be shown that if the c.m.s. angular distribution of the π^0 mesons is represented in the form of a sum of Legendre polynomials

$$\frac{d\sigma}{d\omega} = \sum_l A_l^0 P_l(\cos\vartheta), \tag{1}$$

then the c.m.s. angular distribution of the γ quanta will have the form

$$\frac{d\sigma^\gamma}{d\omega} = \sum_l k_l A_l^0 P_l(\cos\vartheta). \tag{2}$$

The coefficients k_l are determined from the expression

$$k_l = \int_{-1}^{+1} \frac{1-\beta_{\pi^0}^2}{(1-\beta_{\pi^0}\cos x)^2} P_l(\cos x)\, d\cos x, \tag{3}$$

where β_{π^0} is the velocity of the π^0 mesons in the c.m. system. Thus a Legendre polynomial of order l in the angular distribution of the π^0 mesons gives a polynomial of the order l multiplied by the coefficient k_l in the angular distribution of the γ quanta. The experimentally observed cross section for γ quanta is expressed here through the coefficients of the angular distribution of the π^0 mesons in the following way:

$$\left(\frac{d\sigma^\gamma}{d\Omega}\right)_{\rm obs} = \frac{1-\beta^2}{(1-\beta\cos\theta)^2} \sum_l \varepsilon_l(\theta) k_l A_l^0 P_l(\cos y). \tag{4}$$

The coefficient $\epsilon_l(\theta)$ is given by the expression

$$\varepsilon_l(\theta) = \frac{\int_{-1}^{+1} \varepsilon[E(\theta, x)]\,[(1-\beta_{\pi^0}^2)/(1-\beta_{\pi^0}\cos x)^2]\, P_l(\cos x)\, d\cos x}{\int_{-1}^{+1} [(1-\beta_{\pi^0}^2)/(1-\beta_{\pi^0}\cos x)^2]\, P_l(\cos x)\, d\cos x}. \tag{5}$$

In expressions (4) and (5) β is the velocity in the c.m. system, θ is the angle of flight of the γ

FIG. 1. Geometry of the charge-exchange scattering experiment: 1, 2 – scintillation counters 6×6 cm; 3, 4, 5 – scintillation counters 12.6×11.5 cm; 6 – scintillation counter 16×17 cm; 7 – deflecting magnet; 8 – liquid hydrogen.

TABLE I. Values of Q/D observed in one series of measurements of charge-exchange scattering at 240 Mev

Angle in lab system, deg	$Q/D\times10^6$ with H	$Q/D\times10^6$ without H	Difference for 10^6 counts of monitor
15	109.6±2.9	44.9±2.2	64.7±3.7
30	152.3±4.6	45.3±2.5	107.0±5.3
45	113.5±4.1	26.1±2.0	87.4±4.6
60	91.3±2.5	25.9±1.6	65.4±3.0
80	65.3±2.1	21.1±1.4	44.2±2.5
100	53.0±2.2	24.4±1.5	28.6±2.7
125	54.9±1.9	27.2±1.5	27.7±2.4
150	53.6±2.0	31.4±1.5	22.2±2.5

TABLE II. Values of Q/D observed in one series of measurements of charge-exchange scattering at 333 Mev

Angle in lab system, deg	$Q/D\times10^6$ with H	$Q/D\times10^6$ without H	Difference for 10^6 counts of monitor
15	68.3±3.4	29.1±2.2	39.2±4.1
30	129.0±7.6	40.8±2.2	88.2±8.0
45	91.9±5.4	25.4±1.9	66.5±5.7
60	70.0±4.1	26.6±1.8	43.4±4.5
80	40.6±2.8	20.3±1.6	20.3±3.2
112.5	29.2±1.8	19.8±1.1	9.4±2.1
135	29.2±1.6	20.4±1.3	8.8±2.1
152	19.5±0.7	13.0±0.6	6.5±0.8

quanta in the laboratory system, y is the angle of flight of the γ quanta in the c.m. system, $E(\theta, x)$ is the energy of the γ quanta, and $\epsilon(E)$ expresses the dependence of the registration efficiency for γ quanta on their energy.

As can be seen, to obtain the angular distribution of the π^0 mesons (in other words, to determine the coefficients A_l^0,) it is sufficient to know $(d\sigma^\gamma/d\Omega)_{obs}$ for different angles and $\epsilon(E)$. Indeed, $\epsilon_l(\theta)$, k_l, and P_l (cos y) do not depend on the specific form of the angular distribution of the γ quanta. They are determined only by the angle θ, the kinematic relations, and the $\epsilon(E)$ curve. The minimum number of angles θ at which $(d\sigma^\gamma/d\Omega)_{obs}$ should be found depends on the maximum value of l.

For further treatment and phase-shift analysis of the results of the study of charge-exchange scattering, it will be more convenient to use, instead of the coefficients of the angular distributions (1) or (4), the differential cross sections for the $\pi\rightarrow\gamma$ process. In order to obtain the true cross sections from the experimentally observed cross sections, we should know the mean efficiency $\overline{\epsilon(\theta)}$ of registration of γ quanta at a given angle. This mean efficiency is defined by the condition

$$(d\sigma^\gamma/d\Omega)_{\text{obs}} = \overline{\varepsilon(\theta)}\,(d\sigma^\gamma/d\Omega)_{\text{true}}. \quad (6)$$

From (4) and (6), we obtain

$$\frac{1-\beta^2}{(1-\beta\cos\theta)^2}\sum_l \varepsilon_l(\theta)\,k_l A_l^0 P_l(\cos y) = \overline{\varepsilon(\theta)}\,\frac{1-\beta^2}{(1-\beta\cos\theta)^2}\sum_l k_l A_l^0 P_l(\cos y), \quad (7)$$

hence

$$\overline{\varepsilon(\theta)} = \frac{\sum_l \varepsilon_l(\theta)\,k_l A_l^0 P_l(\cos y)}{\sum_l k_l A_l^0 P_l(\cos y)}, \quad (8)$$

in agreement with the mean-value superposition rule.

3. DIFFERENTIAL CROSS SECTIONS FOR CHARGE-EXCHANGE SCATTERING OF 240-, 270-, 307-, AND 333-Mev π^- MESONS ON HYDROGEN

The γ quanta produced in the decay of the π^0 mesons were detected at eight angles. The ratio of the number of $123\overline{4}\overline{6}$ coincidences (Q) to the number of double 12 coincidences (D) was measured. We determined the difference in the ratios Q/D obtained with and without liquid hydrogen in the target. The background conditions during the study of the charge-exchange scattering are illustrated by Tables I and II, which give the respective values of the ratio Q/D observed in one series of measurements at 240 and 333 Mev.

In order to accumulate the necessary statistics, the measurements were made in several series at each energy. The results obtained in the individual series of measurements, after being corrected for errors in the registration of double 12 coincidences, were averaged according to their statistical weight.

In reducing the experimental data, we first calculated the observed differential cross sections from the formula

$$\left(\frac{d\sigma}{d\Omega}\right)_{\text{diff}} = \frac{(Q/D)_{\text{diff}}}{N\Omega f}\cdot 10^{-6}, \quad (9)$$

where $(Q/D)_{\text{diff}}$ is the value of the difference $(Q/D)_{\text{with H}} - (Q/D)_{\text{without H}}$ for 10^6 monitor counts; N is the mean number of hydrogen atoms per cm^3, equal to 0.447×10^{24}, accurate to ±1%; Ω is the solid angle subtended by the telescope; f is the summary correction for contamination of the beam by μ mesons (4.5 — 5.5%), for the finite dimensions of the telescope (to 1.2%), and for the absorption of π^- mesons in counter 2, in the front wall of the target, and in the hydrogen (from 2.2 to 3%).

The errors in determining these corrections, and also other factors affecting the calculated values of the differential cross sections, were not

TABLE III: Differential cross sections for production of γ quanta in charge exchange scattering at 240 Mev on hydrogen

Angle in lab system, deg	Ω, sr	(Q/D) diff	f	$10^{27}\left(\frac{d\sigma}{d\Omega}\right)$ obs in lab system $cm^2\ sr^{-1}$	$\overline{\epsilon(\theta)}$ including normalization of $\epsilon(E)$	$10^{27}\left(\frac{d\sigma}{d\Omega}\right)_{lab}$ $cm^2\ sr^{-1}$	Angle in c.m.s. deg	$10^{27}\left(\frac{d\sigma}{d\omega}\right)_{c.m.s.}$ $cm^2\ sr^{-1}$
15	0.0157	62.5±2.9	0.921	9.67±0.67	0.615	15.72±1.57	19.7	9.31±0.93
30	0.0357	104.1±3,0	0.922	7.08±0.43	0.597	11.86±1.12	38.8	7.54±0.71
45	0.0437	89.9±2,2	0.923	4,99±0,29	0.570	8.75±0.80	57.2	6.20±0.57
60	0.0542	63.8±1.8	0.928	2.84±0.17	0,537	5.29±0.49	74.5	4.28±0.40
80	0.0540	42.2±1.9	0.928	1,88±0.13	0.491	3.83±0.39	95.7	3,75±0,38
100	0.0538	29,2±1.5	0.923	1,32±0.10	0.478	2.75±0.29	114.9	3.24±0,34
125	0.0532	25.5±2.2	0.922	1.16±0,12	0.493	2.36±0.29	136.8	3.38±0.42
150	0.0430	23,3±1.5	0.921	1,32±0.11	0.509	2,59±0.29	157.0	4.23±0.47

TABLE IV. Differential cross section for production of γ quanta in charge-exchange scattering at 270 Mev on hydrogen

Angle in lab system, deg	Ω, sr	(Q/D)diff	f	$10^{27}\left(\frac{d\sigma}{d\Omega}\right)$ obs in lab system $cm^2\ sr^{-1}$	$\overline{\epsilon(\theta)}$ including normalization of $\epsilon(E)$	$10^{27}\left(\frac{d\sigma}{d\Omega}\right)_{lab}$ $cm^2\ sr^{-1}$	Angle in c.m.s., deg	$10^{27}\left(\frac{d\sigma}{d\omega}\right)_{c.m.s.}$ $cm^2\ sr^{-1}$
15	0.0157	55.9±2.3	0,924	8.63±0.58	0.622	13.88±1.36	20.0	7.92±0.78
30	0.0357	91.5±3.2	0.925	6.19±0.39	0.601	10.31±0,97	39.6	6.36±0.60
45	0.0437	74,3±3.0	0.926	4.11±0.27	0,575	7.14±0,69	58.1	4.95±0.48
60	0,0542	52.7±2.0	0.931	2.33±0,15	0.535	4.35±0.52	75.5	3.48±0.42
80	0.0540	27,7±1,6	0,931	1.24±0.10	0,482	2.56±0,26	96.8	2,52±0.26
100	0.0538	20.2±1.2	0.927	0.906±0.074	0,469	1,93±0.21	115.9	2.31±0.25
125	0.0532	19.9±1.6	0,924	0.907±0.086	0.493	1,84±0.22	137.6	2.71±0.33
150	0.0430	16.8±1.3	0,924	0,943±0,088	0.512	1.84±0.22	157.4	3.12±0.37

different from those which were given earlier in Table VIII of reference 4. Since the differential cross sections obtained below were normalized to the total cross section, a number of small corrections (not more than 1%), due primarily to the conversion of the γ quanta and weakly dependent on the energy, were not introduced. The values of the quantities entering into formula (9) are given in Tables III—VI.

After calculation of $(d\sigma^{\gamma}/d\Omega)_{obs}$, the angular distribution of the π^0 mesons in the c.m.system was found in the form of the sum of the first three Legendre polynomials

$$(d\sigma/d\omega)_{\pi^-\to\pi^0} = A_0^0 + A_1^0 P_1(\cos\vartheta) + A_2^0 P_2(\cos\vartheta). \qquad (10)$$

Formula (4) was used to determine the coefficients A_l^0. Since the measurements were made at eight angles, we obtained a system of eight equations with three unknowns, which was solved by the method of least squares. The coefficients A_l^0 for all the energies are given in Table VII.

The initial values of $\epsilon_l(\theta)$ were obtained by numerical integration of the right-hand side of (5). In doing so, the values of $\epsilon(E)$ (curve a in Fig. 2) were taken from reference 2. The values of $\epsilon_l(\theta)$ for 240 and 333 Mev are given in Table VIII. For other energies, $\epsilon_l(\theta)$ can be found with sufficient accuracy by linear interpolation.

The analytical expression for the coefficients k_l, obtained after integration of (3) has the form

$$k_0 = 2, \qquad k_1 = \frac{2\gamma}{\eta} - \frac{1}{\eta^2}\ln\frac{\gamma+\eta}{\gamma-\eta},$$

$$k_2 = 2 + \frac{6}{\eta^2} - \frac{3\gamma}{\eta^3}\ln\frac{\gamma+\eta}{\gamma-\eta},$$

$$k_3 = \frac{2\gamma}{\eta} + \frac{15\gamma}{\eta^3} - \frac{3\gamma}{2\eta^2}\left(\frac{5}{\eta^2} + 4\right)\ln\frac{\gamma+\eta}{\gamma-\eta},$$

$$k_4 = 2 + \frac{95}{3\eta^2} + \frac{35}{\eta^4} - \frac{5\gamma}{\eta^3}\left(\frac{7}{2\eta^2} + 2\right)\ln\frac{\gamma+\eta}{\gamma-\eta}. \qquad (11)$$

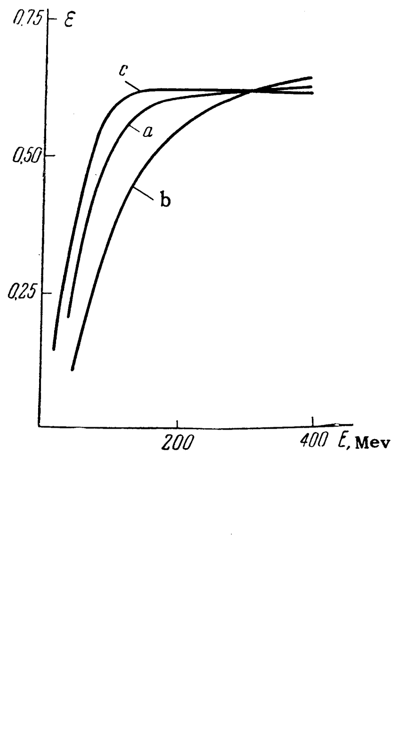

FIG. 2. Variation of efficiency ε of registration of γ quanta with their energy E.

TABLE V. Differential cross section for production of γ quanta in charge-exchange scattering at 307 Mev on hydrogen

Angle in lab system, deg	Ω, sr	$(Q/D)_{diff}$	f	$10^{27}\left(\frac{d\sigma}{d\Omega}\right)_{obs}$ in lab system $cm^2\ sr^{-1}$	$\overline{\epsilon(\theta)}$ including normalization of $\epsilon(E)$	$10^{27}\left(\frac{d\sigma}{d\Omega}\right)_{lab}$ $cm^2\ sr^{-1}$	Angle in c.m.s., deg	$10^{27}\left(\frac{d\sigma}{d\omega}\right)_{c.m.s.}$ $cm^2\ sr^{-1}$
15	0.0120	46.3±2.4	0.930	8.74±0.67	0.629	13.89±1.46	20.5	7.60±0.80
30	0.0360	101.0±14.0	0.931	6.74±0.99	0.609	11.08±1.81	40.4	6,60±1.08
45	0.0440	55.0±5.0	0.934	2.99±0.31	0.582	5.13±0,65	59.2	3.47±0.44
60	0.0550	38.8±3.1	0.941	1.67±0.16	0.540	3.10±0.36	76.8	2.45±0.29
80	0.0550	19.6±1.6	0.942	0.846±0.080	0.476	1.78±0.21	98.0	1,76±0.21
112,5	0.0550	12.6±1.6	0.931	0.551±0.074	0.459	1.20±0.18	128,1	1,66±0.25
135	0.0550	10.2±1.4	0.930	0.447±0.067	0.487	0.917±0.153	146,4	1.50±0.25
152	0.0414	8.95±0.80	0.930	0.521±0.054	0.513	1.015±0.129	159.4	1.81±0.23

TABLE VI. Differential cross section for production of γ quanta in charge-exchange scattering at 333 Mev on hydrogen

Angle in lab system, deg	Ω, sr	$(Q/D)_{diff}$	f	$10^{27}\left(\frac{d\sigma}{d\Omega}\right)_{obs}$ in lab system $cm^2\ sr^{-1}$	$\overline{\epsilon(\theta)}$ including normalization of $\epsilon(E)$	$10^{27}\left(\frac{d\sigma}{d\Omega}\right)_{lab}$ $cm^2\ sr^{-1}$	Angle in c.m.s., deg	$10^{27}\left(\frac{d\sigma}{d\omega}\right)_{c.m.s.}$ $cm^2\ sr^{-1}$
15	0.0120	37.4±3.9	0.932	7.50±0.87	0.628	11.94±1.64	20,8	6,33±0.87
30	0.0360	97.1±4.2	0.932	6.48±0,45	0,612	10,59±1,05	41.0	6.15±0.61
45	0.0440	63.8±5.5	0.935	3.47±0.35	0.586	5.92±0,73	60.0	3.94±0.49
60	0.0550	41.6±4.3	0.943	1.79±0.21	0,550	3.25±0.44	77.7	2.56±0.35
80	0.0550	21.3±2.4	0.945	0.915±0.115	0.489	1.87±0.27	99.0	1,86±0.27
112.5	0.0550	9.16±1.5	0.932	0.400±0.067	0.449	0.889±0.163	128.8	1.25±0.23
135	0.0550	10.1±1.6	0.932	0.440±0.073	0.467	0.942±0.172	146.9	1,58±0.29
152	0.0414	5.83±0.7	0.932	0.338±0.046	0.481	0.703±0.108	159.7	1,29±0.20

TABLE VII. Coefficients A_l^0 found by solving the system of equations (4) by the method of least squares (in units of 10^{-27} $cm^2\ sr^{-1}$)

π^--meson energy, Mev	A_0^0	A_1^0	A_2^0
240	2.56±0,11	1.82±0.28	2.19±0.48
270	2.03±0.10	1.67±0,24	1.97±0.35
307	1.54±0.09	1.73±0.23	1.53±0,30
333	1.56±0.09	1.86±0.22	1.23±0,29

TABLE VIII. Coefficients $\epsilon_l(\theta)$ for 240 and 333 Mev

Angle in lab system, deg	E_{π^-}=240 Mev			E_{π^-}=333 Mev		
	ε_0	ε_1	ε_2	ε_0	ε_1	ε_2
15	0.536	0.605	0.638	0.553	0.610	0.638
30	0.528	0.597	0.634	0.543	0.602	0.634
45	0.520	0.590	0.629	0.533	0.593	0.630
60	0.512	0.582	0.624	0.524	0.585	0.626
80	0.501	0.570	0.618	0.511	0.574	0.621
100	0.490	0.560	0.612	0.498	0.563	0.615
125	0.477	0.547	0.604	0.482	0.549	0.608
150	0.464	0.534	0.597	0.466	0.536	0.601

Here η is the c.m.s. momentum of the π^0 meson in units of $m_{\pi^0}c$; γ is the energy of the π^0 meson in units of $m_{\pi^0}c^2$; correspondingly $\beta_{\pi^0} = \eta/\gamma$. The values of k for 240 — 333 Mev are shown in Table IX.

The three coefficients A_l^0 are quite sufficient to determine the values of $\overline{\epsilon(\theta)}$, to the required accuracy, by means of (8). First, the coefficients of the Legendre polynomials of the higher order are small; second, owing to the fact that $\epsilon_l(\theta)$ for different l do not differ from one another by more than 10 — 20%, $\overline{\epsilon(\theta)}$ is weakly dependent on the oscillations of A_l^0. Thus an arbitrary 15% variation of the coefficients A_l^0 shown in Table VII changes $\overline{\epsilon(\theta)}$ by no more than 1 or 2%.

The correct determination of the "true" differential cross sections depends therefore primarily on the values of $\epsilon_l(\theta)$ and, in the final analysis, on the extent to which the relation found between the registration efficiency for γ quanta and their energy is correct.

To gain an idea of how sensitive $\epsilon_l(\theta)$ and the "true" differential cross sections are to the shape of the $\epsilon(E)$ curve, these quantities were calculated by using for $\epsilon(E)$ a curve different from that taken as the most correct. The change in the calculated differential cross sections for a change in the $\epsilon(E)$ curve goes in two directions: first, there is a change in the shape of the angular distribution, i.e., in the ratio of the forward—backward scattering cross sections; second, there is a change in the total cross section for

TABLE IX. Coefficients k_l for 240 — 333 Mev

Energy, Mev	k_0	k_1	k_2	k_3	k_4	Energy, Mev	k_0	k_1	k_2	k_3	k_4
240	2	1.496	1.051	0.710	0.472	307	2	1.577	1.173	0.858	0.602
270	2	1.534	1.111	0.780	0.534	333	2	1.598	1.207	0.893	0.625

TABLE X. Coefficients of angular distribution of γ quanta (in units of 10^{-27} cm^2 sr^{-1})

π^--meson energy, Mev	A_0^γ	A_1^γ	A_2^γ	M	M_0 (expected)
240	4.79±0.21	2.54±0.39	2.18±0.47	1.67	5
270	3.79±0.18	2.41±0.32	2.07±0.37	0.15	5
307	2.85±0.16	2.58±0.33	1.77±0.32	6.30	5
333	2.87±0.17	2.81±0.32	1.44±0.34	3.40	5

charge-exchange scattering. The latter change is not difficult to calculate, since the total cross section of interaction of π^- mesons with hydrogen and the total cross section for elastic scattering are known [to a greater accuracy than the curve of $\epsilon(E)$]. It turned out that if we use curve b, along with curve a (Fig. 2) and if the obtained differential cross sections are normalized to the same total cross section, then the change in the cross sections at different energies, at angles of 30 and 150° in the laboratory system, is +(5 — 8%) and −(5 — 7%). At other angles the change is still smaller. The shape of curve b was calculated in such a way that it differed from curve a more than it differed from the curve obtained by the Monte-Carlo method.[2] A change in the $\epsilon(E)$ in the other direction (curve c) was less probable, and, at the same time, led to relative changes of less than 7% in the differential cross sections.

In connection with the above, the differential cross sections for charge-exchange scattering, obtained by the use of an $\epsilon(E)$ curve taken from reference 2, were then normalized by a factor common to all energies. The normalizing factor was chosen such that the sums of the total cross sections for elastic[4] and charge-exchange scattering at the energies studied would fit best the total cross sections for the interaction between π^- mesons and hydrogen measured by the absorption of a π^- meson beam in hydrogen[3] at these energies. This factor turned out to be 0.936. The normalization actually meant that the $\epsilon(E)$ curve was normalized, i.e. the efficiency of recording γ quanta at all energies was approximately 6% higher than that taken in the preliminary reduction of the data.

In the determination of the errors in the values of the differential cross sections, the error connected with the inexact knowledge of the shape of the $\epsilon(E)$ curve was taken equal to ± 7%, and was added to the statistical error by the usual rule for combining standard deviations. The error associated with the normalization in the determination of the absolute values of the differential cross sections was, for all energies, ~ 5%. It was not taken into account in the subsequent calculations. The values of $\overline{\epsilon(\theta)}$, with allowance for the normalization of the $\epsilon(E)$ curve and the corresponding differential cross sections for the production of γ quanta emitted at a given angle, are listed in Tables III — VI.

To determine the angular distribution of the π^0 mesons, we now represent the c.m.s. angular distribution of the γ quanta in the form of a sum of Legendre polynomials:

TABLE XI. Coefficients of angular distribution of π^0 mesons (in units of 10^{-27} cm^2 sr^{-1})

π^--meson energy, Mev	A_0^0	A_1^0	A_2^0	Total charge-exchange cross section
240	2.39±0.11	1.70±0.26	2.07±0.45	30.0±1.4
270	1.90±0.09	1.57±0.21	1.86±0.33	23.9±1.1
307	1.42±0.08	1.64±0.21	1.51±0.27	17.8±1.0
333	1.43±0.09	1.76±0.20	1.19±0.28	18.0±1.1

$$\frac{d\sigma^{\gamma}}{d\omega}=\sum_{l} A_l^{\gamma} P_l(\cos y). \qquad (12)$$

The coefficients A_l^0 obtained by the method of least squares are given in Table X for the case $l = 2$.

The values of the sum of the weighted squared deviations indicate that the three Legendre polynomials quite satisfactorily describe, at all energies, the observed angular distribution of the γ quanta. The values of M obtained at 240 and 270 Mev were small in comparison with the expected values, possibly because the error of ±7%, due to the inexact knowledge of $\epsilon(E)$, was somewhat exaggerated, while the statistical accuracy of the measurements was sufficiently good (~ 2.5 — 6%).

Knowing the coefficients A_l^0, we could determine the coefficients of the angular distribution of the π^0 mesons. Using the values of k_l included in Table IX, we obtain the coefficients A_l^0 listed in Table XI.

The last column of Table XI gives the total cross sections for charge-exchange scattering, obtained by integrating the angular distributions.

A phase-shift analysis of the experimental data is presented in the following article.

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