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Publication Date
1952-02-01

UCRL-1665

UNCLASSIFIED

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UCRL-1665
Unclassified-Physics Distribution

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Contract No. W-7405-eng-48

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February 1, 1952

Berkeley, California

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The photo-dissociation of the alpha particle by high energy synchrotron gamma-rays of a maximum energy of 320 Mev was studied by the method used in the study of the photo-dissociation of the deuteron reported previously.[1] The analysis was made on the proton tracks found in photographic emulsions exposed to the secondary particles emitted from a gas target of helium. The exposure had been made originally by M. J. Jakobsen et al.,[2] to investigate the photomeson production of the helium nucleus. Because of fairly large experimental error the conclusions are not entirely free from ambiguities. It seems, however, difficult to get more accurate results before the intensity of the synchrotron beam is improved considerably. Therefore, it was considered worthwhile to present the results in spite of their lack of completeness.

The energy spectra of the protons at the emission angles of 45°, 90° and 135° are shown in the accompanying table together with the data for the deuteron previously reported.[1] The values are corrected for the nuclear absorption of protons in the absorbing material. To make the numbers in the cases of deuteron and alpha particle comparable they are normalized to the number of protons in the nucleus concerned. The data available in the helium case are less complete than those in the deuteron case.

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1. S. Kikuchi, Bull. Am. Phys. Soc. 26, 5 (1951).
2. M. J. Jakobsen et al., Bull. Am. Phys. Soc. 26, 24 (1951).

In the case of 45°, there seems to be a fairly well defined cutoff at the energy almost equal to the cutoff energy of the deuteron which is approximately 200 Mev. The yield corresponding to a proton energy of about 160 Mev is nearly equal in both cases. In the case of helium the yield of protons below 140 Mev increases more steeply with decreasing energy than in the case of the deuteron, indicating the existence of more low energy protons.

In the case of 90°, the cutoff energy is again nearly the same in both cases. The energy distribution curve below the cutoff energy in the helium case shows a steady increase of the number of protons with decreasing energy, leaving no plateau below the cutoff, indicating again the larger number of protons below about 140 Mev.

In the case of 135°, the energy spectrum extends up to about 130 Mev, which is higher than the cutoff energy of the deuteron case.

The conclusions one can draw from these data might be as follows. The facts that the cutoff energies of the spectra of protons at 45° and 90° are approximately the same as in the case of deuteron, seem to indicate that the high energy protons at least in the case of 45° are produced by the absorption of a photon in a two nucleon system. The existence of protons of energy higher than the cutoff energy of the deuteron in the case of 135° might be due to an absorption process in which the energy and momentum of a photon is taken up by three or four nucleons. The fact that there are more protons below say 140 Mev at the emission angles of 45° and 90° in the case of helium than in the case of deuterium, might also be explained by the three or four nucleon process mentioned above. The lack of protons above the cutoff energy for the two nucleon process in the case of 45° and 90° and the lack of protons of energy above about 130 Mev in the case of

135°, seem to indicate that the cross section for the process such as $He + \gamma \rightarrow T + P$ is small compared to the two nucleon process. They also indicate the small probability for a process such as $He + \gamma \rightarrow 2P + 2N$ or $He + \gamma \rightarrow D + P + N$, in which the proton gets more energy than allowed by the two nucleon process.

The present results, together with the previous results on the deuteron, should help to provide a fundamental basis for interpreting the photo-dissociation phenomenon of nuclei in general by high energy gamma-rays.

The author thanks Professors McMillan and Helmholz and members of the synchrotron group for the helpful discussions as well as for the generosity in placing the plates at the author's disposal.

Information Division
2/1/52 bm

TABLE

Angle	Energy (Mev)	Deuteron	-particle
45°	78		26.2±2.9
	80	18.7±1.7	
	87	15.6±1.6	
	93	9.0±1.4	17.7±2.0
	99	12.3±2.5	
	103	8.6±1.5	17.4±2.1
	116	6.8±1.2	
	126	7.3±1.3	
	141	5.8±1.3	
	154		6.4±1.3
	165		5.5±1.4
	177	6.7±1.6	
	189	8.5±1.6	
	205	3.5±1.8	6.4±1.4
	216	2.3±1.6	2.8±1.2
	241		3.3±1.5
	258		1.9±1.1
	320	2.6±1.1	
90°	68		11.7±1.7
	72	5.2±0.8	
	80	4.1±0.8	
	86	3.9±0.8	7.3±1.1
	93	4.8±1.0	
	99	6.3±1.3	9.0±1.6
	108	5.9±1.6	6.5±1.2
	117	5.7±1.7	6.0±1.3
	125	3.7±1.4	
	132	2.4±1.2	3.9±0.9
	143	2.1±0.7	
	161	0.67±.47	
	172		1.3±0.4
	182	1.2±0.7	
135°	84		4.5±0.9
	86	3.7 0.8	3.5±0.8
	92	3.4 0.8	3.5±0.8
	98	2.7 0.8	5.6±1.2
	103	2.8 0.9	3.6±1.0
	116	0.6 0.4	2.9±0.8
	122		2.2±0.7
	127		1.6±0.6
	134		1.3±0.6
	140	1.7 0.7	1.1±0.4