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Disintegration of Beryllium and Carbon Nuclei as a Result of π^--Meson Capture

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TO obtain information on the disintegration of light nuclei in stopping π^--mesons, an investigation was carried out on σ-stars in beryllium and carbon. Powdered beryllium and carbon (crystal size $5-10\ \mu$) were introduced into the emulsion to the amount $4\ \mu$ gm per cm.[3] The method developed for introducing the powders guaranteed a uniform distribution of the crystals over the emulsion layer. A plate of total thickness $2-2.5$ mm was prepared from emulsion layers of diameter 42 mm,

The powder of the material under investigation was contained in only $3-4$ layers out of 10. The plates were exposed to a beam of slow π^--mesons in the synchrocyclotron of the Institute for Nuclear Problems of the Academy of Sciences, USSR. The method of processing the layers[1] differed little from the procedures used previously for the processing of emulsions in layers.[2] (The work was completed in 1953.[3]) A layer with beryllium was fixed at low temperature $\beta \sim 5°$) to preserve the blackening.

Each fixed case which resembled the nuclear absorption of a pion in the crystal was subjected to processing under a microscope. After all the necessary measurements had been completed, the tracks were again subjected to examination. For improvement of the visibility of the layer, the emulsion below the crystal was removed with chamois and wetted in a solution of methyl alcohol in ethyl. We succeeded in reducing the layer to several microns thickness. The emulsion was soaked in water at the place under investigation and was examined (in swollen condition) under the microscope. Only by means of such careful testing could it be reliably established whether the pion was absorbed in the crystal.

As a result of the investigation of 4 cm^3 of the emulsion, 7 cases of pion absorption in carbon and 12 in beryllium were observed. In the analysis of the tracks, we used a method of counting the grains on some plates and the δ-electrons on the others as functions of the remaining range of the particles. Singly-charged particles differed from doubly-charged ones in the remaining range by more than 50-100 μ. Information on the particles which arise in the nuclear disintegrations of carbon and beryllium are shown in Tables 1 and 2, respectively. The symbols H, p, d, T, α and f denote, respectively, singly-charged particles, protons, deuterons, tritons, doubly-charged particles and particles with short tracks, which could not be identified.

The average number of prongs in the stars in beryllium amounted to 1.15 ± 0.23. In nearly one fourth the cases (28 ± 12 %), the absorption of the pion did not lead to the release of charged particles. In each disintegration of a Be

TABLE 1

Number of prongs in the star	Nature of particles	Energy of particles in mev (range in μ)
0	—	—
1	p	14
1	f	(46)
2	p, α	10,10
2	α, f	12, (14)
3	p, f, f	19, (70), (12)
4	H. H. f. f	5.5. 4.7, (24), (37)

TABLE 2

Single-pronged stars		Double-pronged stars		Triple-pronged stars	
particle symbol	energy in mev (range in μ)	particle symbol	energy in mev (range in μ)	particle symbol	energy in mev (range in μ)
p	>21	α	11	p	19
p	11	p	9.5	p	16
H	6	α	11		0.9—1.2
α	13	H (d,T)	4.5—5.5	W	W
f	(17)	α	9	H	6
f	(8.5)	H (d,T)	8.5—9.5	H	1
f	(5.5)	f	(22)	H	3- -2
f	(3)	H	2—3	—	—
—	—	f	(15)	—	—
—	—	f	(4.5)	—	—

nucleus, there arose, on the average, not more than one single charged particle, the mean energy of the charged particles being 5-10 mev.

In such a light nucleus as Be, the particles which receive the energy in the initial act in the distribution of the rest pion between the nucleons, cannot undergo a large number of collisions with the rest of the nucleus. Consequently, in the energy spectrum of the particles emitted in the disintegration of the nucleus, one can make a direct judgement on the spectrum of primary particles.

Among the particles which are emitted from the star in Be and C, there are absent tritons with energy > 10 mev. Consequently, fast tritons are not observed in the primary acts in a significant number of cases. The data obtained do not agree with the model in which the pion is absorbed by a system similar to He^4, as a result of which a neutron is formed with energy ~ 95 mev and a triton with energy ~ mev.[4] This model also contradicts the fact that absorption of the pion by beryllium fairly frequently fails to result in the emission of charged particles.

A differeet model was proposed by Menon,[5] in which the pion was absorbed by a group of He^4 with a subsequent uniform distribution of energy among the four nucleons (three neutrons and a proton). From the point of view of this model, the absence in σ -stars in Be and C of a large number of tracks of protons with energy 20-40 mev remains unexplained (mean energy of the emitted protons does not exceed 10 mev).

The energy released in the emission of charged particles in the disintegraiion of a Be nucleus is equal on the average to 10-15 mev. Almost ten times more energy is released in the emission of neutral particles than in the emission of charged particles.

The resultant experimental information on σ -stars in Be and C testifies to the fact that 1 or 2 neutrons receive a large part of the energy of the rest pion. In such a light nucleus as Be, they rarely undergo collisions and thus retain an appreciable part of the energy without transmitting it to charged particles.

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The Disintegration and Mass Difference of Heavy Neutral Mesons

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IN the researches of Pais, Gell-Mann and Piccioni[1,2] there were forecast very interesting characteristics of the behavior of heavy neutral