EMISSION OF Li^8 *FRAGMENTS IN THE DISINTEGRATION OF Ag AND Br NUCLEI BY 19-BeV PROTONS*

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The production of Li^8 fragments on Ag and Br nuclei induced in nuclear emulsions by 19-BeV protons was investigated. Such fundamental characteristics of the emission process of Li^8 fragments in disintegrations with a number of black prongs $N_b \geq 8$ as the yield per disintegration, the energy and angular distributions and some data on the emission of two fragments in a single disintegration are presented. A comparison of the data of the process for various primary-proton energies shows that in a broad energy range the main characteristics of the process remain the same.

NOTWITHSTANDING the numerous investigations of fragment emission in nuclear disintegrations, the experimental data relating to this phenomenon are in need of considerable amplification and refinement. This is in particular also true of the investigation of Li^8 fragments whose emission was investigated by various methods and at various incident-particle energies.

We have previously[1] investigated Li^8 fragment emission induced by 9-BeV protons. The characteristics obtained in that work—the fragment yield per disintegration, the energy and angular distributions—turned out to be consistent with the evaporation theory. Similar investigations employing somewhat different methods for the selection of stars were carried out at a proton energy of about 25 MeV.[2] In these papers a certain deviation was noted of the observed energy spectrum and angular distribution from the predictions of the evaporation theory for fragments with energies larger than 40—50 MeV.

In this article we present data on the emission of Li^8 fragments in the disintegration of Ag and Br nuclei in emulsion caused by protons with an energy of 18.9 ± 0.4 BeV. In the area scanning of NIKFI-R type emulsions 400 μ thick we registered 19,283 stars with $N_b \geq 8$ black prongs, including 395 stars with one hammer-like track and six stars with two such tracks. As in [1], it was assumed that all hammer-like tracks belong to Li^8. The method of searching for events and their subsequent processing was the same as previously.[1]

The scanning results are presented in the table, the last column of which indicates the yield of Li^8 fragments per disintegration as a function of the number of black prongs. Also presented are the numbers of fragments obtained after the introduction of a correction for the loss of particles due to the finite thickness of the emulsion layer. As can be seen from the table, at a proton energy of 19 BeV the Li^8 fragments are emitted in the investigated stars in 2.5 percent of the cases, which coincides with the 2.7 percent obtained for such stars at an energy of 9 BeV.[1] The yields indicated in the table for disintegrations with a different number of black prongs also coincide with the values for 9-BeV protons.

N_b	$\overline{N}_b$	Number of stars	Number of Li^8 fragments	Corrected number of fragments	Yield
8—10	8.9	7876	98	117	0.015±0.002
11—13	11.9	5814	102	122	0.021±0.002
14—16	14.9	3226	95	114	0.035±0.004
17—19	17.8	1571	72	86	0.054±0.006
20—22	20.8	580	30	36	0.062±0.011
23—33	24.5	216	10	12	0.056±0.018
	Total	19283	407	487	

The energy distribution of the Li^8 fragments with account of the correction for the loss of fragments resulting from the finite thickness of the emulsion layer is given in Fig. 1, in which curves are also presented calculated in accordance with evaporation theory for a nucleus at rest and for a nucleus moving with a velocity v = 0.015 c; the temperature of the nucleus T and the potential barrier V were assumed to be 10 and 5 MeV respectively. This distribution is similar to the distribution for 9-BeV protons, and, like the latter, it is better described by the curve of the evaporation process when the motion of the nucleus is allowed for than without allowance for it. It is interesting to note that the upper limits of the energy spectra for various energies of the primary protons coincide. In the disintegration of Ag and Br nuclei by protons with energies 2.2[3], 9[1], and 25[2] BeV the upper limits of the energy spectra of the fragments are close to 100 MeV. The same upper limit is found in this work at an energy of 19 BeV and in the cosmic-ray investigations of Skjeggestad and Sörensen[4].

The angular distribution of Li^8 fragments is shown in Fig. 2 for two segments of the energy spectrum, E ≥ 21 MeV and E < 21 MeV. Both histograms are satisfactorily described by curves calculated according to the evaporation theory with allowance for the motion of the nucleus with a velocity v = 0.015 c, and are evidence for the isotropic emission of fragments in the rest system of the nucleus. Just as in the case of 9-BeV protons, the anisotropy of the angular distribution of fragments in the laboratory system remains unchanged in a broad range of change in the number of black prongs. This follows from a comparison of the number of fragments in the forward and backward hemisphere for 8 ≤ N_b ≤ 12 and N_b ≥ 18. For these two intervals the corresponding forward-backward ratios are 1.6 ± 0.4 and 1.7 ± 0.5.

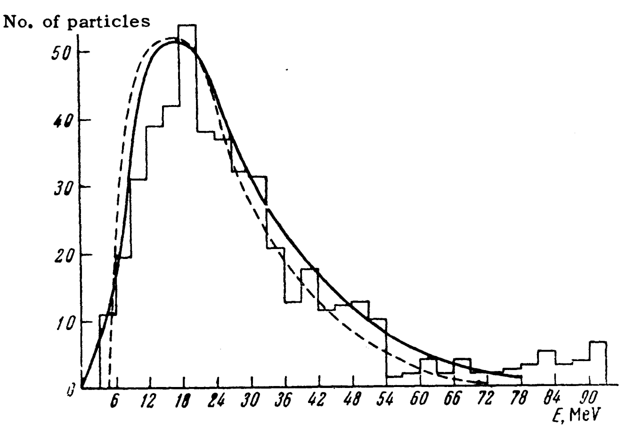

FIG. 1. Energy distribution of Li^8. Solid curve – T = 10 MeV, V = 5 MeV, v = 0.015 c; dashed curve – T = 10 MeV, V = 5 MeV, v = 0.

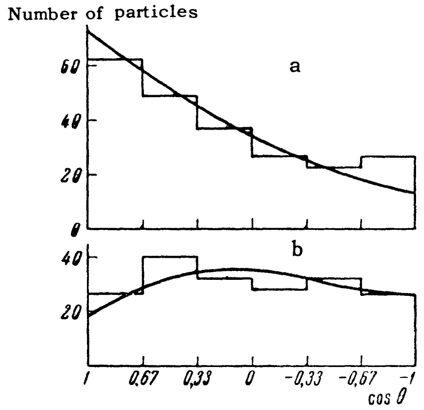

FIG. 2. Angular distribution of Li^8 fragments (θ – emission angle of the fragment in the laboratory system): a – for E ≥ 21 MeV, b – for E < 21 MeV. Solid curves – calculated for T = 10 MeV, V = 5 MeV, v = 0.015 c.

The question of a possible correlation between the directions of emission of fragments in disintegrations including two fragments is of interest. To increase the statistics we have added to the six cases with two fragments found in the present work cases taken from other papers referring to 9-BeV protons.[1,5] Figure 3 shows the distribution of solid angles between fragments in 20 events. The mean angle between fragments amounts to about 75°. In the same figure the smooth curve indicates the expected distribution in the case of independent particle emission calculated by the Monte-Carlo method under the assumption that the angular distribution of each fragment is identical with the distribution when they are emitted singly. Figure 3 shows no clear deviation of the distribution of angles between the fragments from a random distribution. It can therefore be assumed that the emission of each of the two Li^8 fragments in a single disintegration occurs independently.

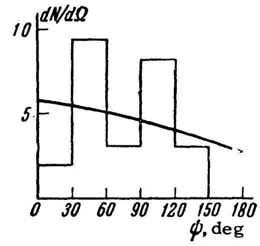

FIG. 3. Distribution of solid angles between two Li^8 fragments (ψ – solid angle between the fragments, dN/dΩ – number of particles per unit solid angle). Solid curve – calculation for the case of independent fragment emission.

In connection with the existing treatments of the fragmentation process as a fast process occurring within a time comparable with the nuclear time (see, for example, [6]) it must be noted that a similar view may indeed not be justified in the case of the process of emission of Li^8 fragments from Ag and Br nuclei under the action of high-energy protons. This fragment is, apparently, emitted some time after the collision of the proton with the nucleus. This view is favored by the independence of the yield and of the energy spectra of the energy of the primary protons, and by the apparently independent emission of fragments in disintegrations containing two fragments.

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