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Abstract

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OBSERVATION OF THE DECAY OF THE NUCLEUS B_5^9 IN NUCLEAR EMULSION

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In examining nuclear emulsions irradiated with high-energy protons, we recorded 4 cases in which a multiply charged particle, at the end of its range, decays into 3 charged particles. The decay is observed at the end of the cone-shaped track of the primary particle, which excludes the possibility of explaining the cases under consideration as nuclear fragmentation. Comparison of the tracks of these particles with tracks of particles of known nature showed that the charge of the primary particle is equal to 5 or 6. Two secondary tracks are similar to the tracks of α particles from the decay of Be_4^8 observed in emulsion; the third track was identified as the track of a singly charged particle. Assuming that the two short secondary tracks belong to α particles and one to a proton, the energies of these particles were determined. The characteristics of the cases are given in Table 1.

Table 1

Case No.	Length of primary track, μ	Ranges, μ $-\alpha$ particles	Ranges, μ $-$ proton	Energy, MeV $-\alpha$ particles	Energy, MeV $-$proton	Excitation energy of B_5^9, MeV	Excitation energy of Be_4^8, MeV	Type of splitting
1	35.5	3.11.6	13.0	0.90.5	0.9	2.0	1.3	Single track f
2	15	3.13.5	6.1	0.91.1	0.6	2.3	1.9	Star $2p+f$
3	68	8.47.1	15.1	2.32.0	1.05	5.0	4.1	Star $1p+f$
4	102	3.33.7	14.0	1.01.2	1.0	2.9	2.1	Star, 16 prongs

Cases 1-3 were found in P-9 emulsion, insensitive to electrons, which was irradiated with protons of energy 660 MeV; case 4 was found in electron-sensitive PR emulsion exposed to a proton beam of energy 9 BeV. In the latter case, in addition to the tracks of heavy particles, there is observed the track of a fast electron emerging from the center of the secondary star and, possibly, one more track of a relativistic electron separated from the center of the secondary star by a considerable distance.

Table 1 indicates the type of splitting in which an unstable fragment is emitted. A check showed that the total momentum of all three secondary particles (assuming that 2 α particles and one proton are emitted) is in all cases close to zero to an accuracy of 5-10%. Consequently, neutron emission does not occur (at least with an energy greater than 0.2 MeV). It could be assumed that the observed cases are examples of the decay of the nucleus B_5^8 according to the scheme

$$B_5^8 \xrightarrow{\beta} Be_4^8 \to 2\alpha',$$

with the appearance of a proton at the point of separation of the α particles being the result of an elastic collision of one of the α particles with a hydrogen atom. It could also be admitted that elastic scattering of the fragment B_5^8 on a hydrogen nucleus of the gelatin had occurred.

with a large transfer of energy to the latter. However, a simple calculation shows that neither of these possibilities is realized in the observed cases. First, this follows from the angular and energy relations of the α particles and the proton; second, from probabilistic considerations (the probability of elastic scattering of an α particle on hydrogen over a length of no more than $1\,\mu$ from the point of decay of Be_4^8 is of the order of 10^{-6}, which, given the available statistics of Be_4^8 decay cases, makes this supposition unrealistic). The second possibility is also excluded by the consideration that the fragment after scattering on a proton would have a sufficient range, and the point of decay of Be_4^8 and the beginning of the proton track would be separated by a distinctly observable interval of 2-$3\,\mu$.

It is therefore natural to consider all the indicated cases as examples of the disintegration of the nucleus B_5^9 according to the scheme

$$B_5^9 \to Be_4^8 + p. \tag{1}$$

The fact that the energies of the α particles in each pair are rather close to one another suggests that the decay proceeds through the intermediate nucleus Be_4^8. The values of the excitation energy of Be_4^8 are given in Table 1. From the known masses of the particles participating in process (1), and from the sum of their kinetic energies, one can estimate the excitation energy of the nucleus B_5^9 (see Table 1). The values obtained turn out to be close to the known levels of B_5^9: 2.3, 2.9, and 4.9 MeV (1). The values of the excitation energy of Be_4^8 apparently correspond to the broad level at 2.9 MeV (width about 1 MeV). It is surprising that the decay of B_5^9 proceeds to the first excited level of the nucleus Be_4^8 even when the initial energy is sufficient only for transition to the "tail" of the resonance curve of the level, and that among the 3 observed cases with low excitation energy of B_5^9 (2.3 and 2.9 MeV) there is not a single one in which the ground state of Be_4^8 would be realized, although in this case the energy release would be considerably larger. If this is not a matter of statistical fluctuation, then it remains to assume that there is a prohibition on the transition of B_5^9 to the ground state of Be_4^8 because of the large difference in spins.

Since the spin of the nucleus Be_4^8 is zero, and that of the first excited level is two, it follows from the above supposition that the first excitation levels of the nucleus B_5^9 have large spins, so that the transition to the ground state of Be_4^8 is associated with the emission of a proton with a large orbital angular momentum. From the observed range of the fragments one can determine their time of flight before stopping, which gives a lower limit on the lifetime of the unstable nucleus (of the order of 10^{-12} sec). This value is too large for it to be possible to take it as the lifetime of the nucleus B_5^9. Most likely we are dealing with the appearance, in nuclear disintegrations, of nuclei C_6^9, which by β decay transform into the nucleus B_5^9. A similar case was found in Ref. (2). We note that the energy release in the decay of B_5^9 discovered in (2) was considerably larger (more than 12 MeV). Case 4, containing the track of a fast electron, supports the hypothesis of β decay of the nucleus C_6^9.

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CITED LITERATURE

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Note: Figure translations are in progress. See original paper for figures.