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HIGH-ENERGY FRAGMENTS EMITTED DURING THE ABSORPTION OF SLOW π^- MESONS BY O^{16} NUCLEI

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The disintegration of a nucleus by a slow π meson is analyzed. The analysis indicates that the O^{16} nucleus is disintegrated into Li^8, Be^7 and n^1. The kinematic characteristics of the disintegration products are such that the Li^7 and Be^7 fragments could be produced only as a result of direct-interaction between the π meson and two nucleon groups, the masses of which are approximately equal to the masses of the observed fragments.

WE registered 646 nuclear disintegrations accompanied by the production of Li^8 in NIKFI Ya-2 nuclear emulsions exposed to slow pions in the meson beam of the synchrocyclotron of the Joint Institute for Nuclear Research. We describe here one of these cases, worthy in our opinion of special analysis.

A microphotograph of this case is shown in the figure. The π^- meson stopped in the emulsion caused a nuclear disintegration accompanied by production of two charged particles. One was a Li^8 fragment (decay into two α particles is observed on the end of the path). The track density of the second particle indicates that its charge is ≥ 2. The lengths of the tracks are 154 and 110 μ respectively. The angle between tracks is 170°.

The relatively low probability of emission of charged particles by the heavy nuclei, due to the large Coulomb barrier, leads us to assume that we are dealing in this case with disintegration of a light nucleus. This assumption can be checked and refined by using the energy and momentum conservation laws. The nuclear emulsion contains appreciable amounts of only three light nuclei, namely C^{12}, N^{14}, and O^{16}. Thus, the following three reactions should be considered:

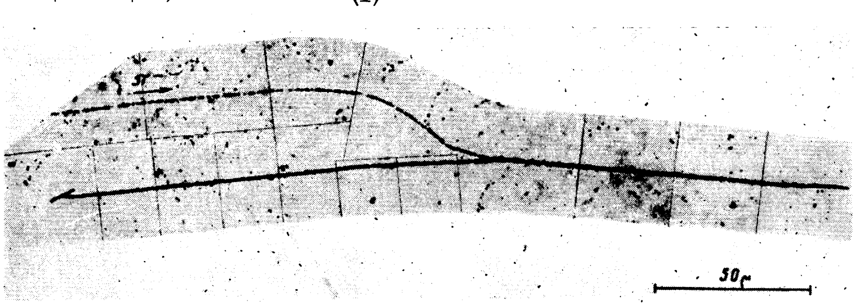
$$C^{12} + \pi^- \rightarrow Li^8 + He^3 + n, \qquad (1)$$

$$N^{14} + \pi^- \rightarrow Li^8 + Li^5 + n, \qquad (2)$$

$$O^{16} + \pi^- \rightarrow Li^8 + Be^7 + n. \qquad (3)$$

Reaction (2) cannot produce a two-prong star, because Li^5 decays into an α particle and a proton, and consequently should be excluded from consideration. For each of the remaining two reactions, we determined the total energy that must be imparted to the nucleus to obtain disintegration with fragment ranges equal to those experimentally observed. The fragment energies were determined from their ranges, using the data of Papineau[1]. The neutron energy was calculated from the momentum conservation law (the meson momentum can be assumed to be zero with a great degree of accuracy). The total energy released in the reaction, and actually responsible for the disintegration analyzed here, should equal the rest energy of the π^- meson (139.6 MeV). Actually we obtained 216 MeV for reaction (1) and 139.3 MeV for reaction (3).

Thus, only reaction (3) agrees with the energy conservation law. We consider this reaction to be responsible for our case of nuclear disintegration. The values obtained for the reaction-product energies are E_{Li} = 38.4 MeV, E_{Be} = 41.6 MeV, and E_n = 9.3 MeV. We see from these figures



that almost all the energy left after subtracting the binding energy loss (50 MeV) is transferred to the two fragments Li^8 and Be^7. The fragment momenta are nearly equal (756 and 736 MeV/c, respectively) and their relative angle is close to 180°.

To satisfy energy and momentum conservation in our reaction, we must assume that as the meson is absorbed the greater part of its rest energy is directly acquired by two groups of nucleons, with masses equal (or in any case close) to the masses of the observed fragments. If we do not assume the existence of long-range nuclear forces, the mechanism in such a process can be connected only with the existence of sharply pronounced space correlations of large groups of nucleons within the nucleus, with these groups interacting as a unit. Similar processes in heavy nuclei can result in fragments with energies greater than 100 MeV. It is possible that an appreciable fraction of the fragments observed in the disintegration of nuclei by high-energy particles is due precisely to the creation and absorption of mesons as the cascade develops inside the nucleus (see [2]).

[1] A. Papineau, Compt. rend. **242**, 2933 (1956).

[2] Denisov, Kosareva, and Cerenkov, Trudy Tashkentskoĭ konferentsii po mirnomu ispol'zovaniyu atomnoĭ energii (Transactions of the Tashkent Conference on Peaceful Use of Atomic Energy), Tashkent **1**, 117 (1961).

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