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COMPARISON OF THE EXCITATION ENERGIES OF B^{11} PRODUCED IN THE REACTIONS $C^{12}(\pi^-, n)B^{11}$ AND $C^{12}(p, 2p)B^{11}$

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The excitation energies of B^{11} from the reaction $C^{12}(\pi^-, n)B^{11}$ were measured in nuclear emulsion for two channels of B^{11} decay. B^{11} decays into two α particles and a triton in one case and into Li^8 and He^3 in the second. The results are compared with the B^{11} excitation energy distribution in the $C^{12}(p, 2p)B^{11}$ reaction. The results of measurements of both reactions are found to be in satisfactory agreement. A possible mechanism for the excitation of nuclei at energies of 25—40 MeV is considered.

In Ilford C-2 and NIKFI Ya-2 emulsions exposed to slow π^- mesons, we studied the reactions

$$C^{12} + \pi^- \rightarrow 2He^4 + H^3 + n, \qquad (1)$$

$$C^{12} + \pi^- \rightarrow Li^8 + He^3 + n. \qquad (2)$$

Reaction (1) was identified with the aid of the laws of conservation of energy and momentum. Analysis of the track density of singly charged particles confirmed the correctness of the identification in most cases. Reaction (2) is readily identified in emulsion by the characteristic lithium-hammer tracks. Moreover, the correctness of the identification in this case was also established with the aid of the laws of conservation of energy and momentum. Investigation of the kinematic characteristics of the charged particles showed that these particles are produced as a result of the decay of a residual nucleus whose momentum is equal to the momentum of the neutron. In both reactions, the residual nucleus is B^{11}.

Figure 1 shows a histogram of the distribution of the B^{11} excitation energy [the distribution for reaction (2) is shown shaded]. The B^{11} decay threshold is 11 MeV in reaction (1) and 27 MeV in reaction (2). Despite the rather large difference in thresholds, both distributions have the same shape in the region of high excitation energies. This indicates that the rapid drop of the distributions in the energy region > 35 MeV is due not to the specific characteristics of the B^{11} decay in the two channels, but to its mechanism of production. It is of interest to compare the results here with those obtained for reactions produced by other primary particles. Unfortunately, at the present time there is only one paper with which such a comparison can be made. Tyren, Hillman, and Maris[1] bombarded C^{12} with 185-Mev protons and measured the B^{11} excitation energy in the reaction $C^{12}(p, 2p)B^{11}$. The distribution for the energy region > 11 MeV obtained in this work is shown in Fig. 1 as a smooth curve. It is seen that our results are in very good agreement with the results of these authors. It should be mentioned that they were inclined to interpret the peak at the excitation energies 30—40 MeV as a contribution from the reaction (p, pd). This suggestion, however, is not well founded. Furthermore, in [1] the peak in the excitation region 30—40 already appears for Be^9 and B^{11}, although in this case the (p, pd) reaction cannot lead to its occurrence at such energies.

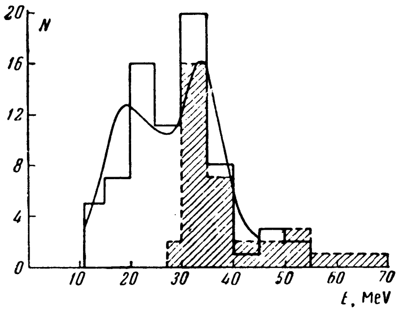

FIG. 1.

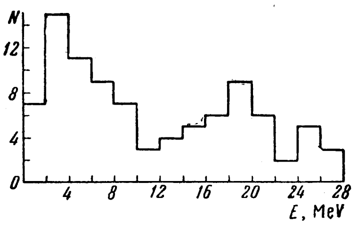

FIG. 2.

The good agreement of the results obtained for different reactions suggests the existence of some mechanism for the excitaion of residual nuclei which becomes important at high energies. Such a mechanism, in our opinion, can be the transition of nucleon pairs from shells of lower energy to shells of higher energy. In the reactions studied by us, the most probable transition is from the p shell to the 2s shell. The greater intensity of the nucleon-pair transitions can be explained in this case by the lack of a change of the total angular momentum or parity, and, consequently, such transitions are allowed for any states of the other nucleons taking part in the reaction.

If this suggestion is correct, we should expect that, in the reactions studied by us, the B^{11} states in the region of high excitation energies will be mainly odd (one nucleon is removed from the p shell). The decay of odd states of B^{11} in reaction (1) through Be^8 is unlikely, since the Be^8 wave function should be even, and, consequently, in such a decay the tritons, which are comparatively slow in our case, should be emitted in the p state. Hence, it is to be expected that the B^{11} decay occurs primarily through Li^7. The α particles emitted in the B^{11} decay should on the average have greater energies than in the Li^7 decay since in the former case the α-particle momentum is offset by the Li^7 nucleus, and in the latter by the triton. Moreover, in the B^{11} decay there is a greater reserve of energy which can be transferred to the decay products. Figure 2 represents the spectrum of α particles produced in reaction (1) for cases in which the B^{11} excitation energy exceeds 25 MeV. The two energy groups of α particles observed in the spectrum are in agreement with the foregoing proposals on the nature of the reaction.

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[1] Tyrén, Hillman, and Maris, Nuclear Phys. **7**, 10 (1958).

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