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Clustering Features of the ^{7}Be Nucleus in Relativistic Fragmentation

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Abstract Charge topology of fragmentation of 1.2 A GeV ^{7}Be nuclei in nuclear track emulsion is presented. The dissociation channels ^{4}He + ^{3}He, 2^{3}He+ n, ^{4}He + 2^{1}H are considered in detail. It is established that the events ^{6}Be + n amount about to 27 % in the channel ^{4}He + 2^{1}H.

1 Experiment and Results

Stacks of pellicles of nuclear track emulsion provide a special opportunity to explore clustering of light nuclei (reviewed in [1]). The presented results on dissociation of ^{7}Be nuclei are demonstrate the progress in research carried out by the BECQUEREL Collaboration. The ^{7}Be nucleus is a source for the study of the states ^{3}He + ^{4}He, ^{3}He + ^{3}He + n, ^{6}Li + p and ^{6}Be + n. The pattern of fragmentation is important for understanding of the structure features of the nuclei ^{8}B, ^{9}C and ^{12}N because the ^{7}Be nucleus plays the role of a core in them.

Nuclear track emulsion was irradiated at the Nuclotron of the Joint Institute for Nuclear Research (JINR, Dubna) by a mixed beam of ^{7}Be, ^{10}C, and ^{12}N nuclei which was created by selecting products of charge–exchange and fragmentation processes involving ^{12}C nuclei accelerated to an energy of 1.2 GeV per nucleon [2–5]. Viewing of the exposed pellicles and the track classification made it possible to establish the charge topology of the ^{7}Be nucleus. Peripheral fragmentation distribution of the 289 found events N_{ws} not accompanied by target fragments ("white" stars) is presented in Table 1 over the fragmentation channels as well as 380 events N_{tf} accompanied by target fragments.

The distribution of the 79 events 2He which were successfully identified by multiple scattering is presented in Table 2. It gives an idea about the relationship configurations ^{3}He + ^{4}He and 2^{3}He + n in the ^{7}Be structure, as the identification was carried out without bias. The channel ^{3}He + ^{4}He dominates over 2^{3}He indicating on a higher probability of the two-body configuration ^{3}He + ^{4}He in the ^{7}Be structure compared to 2^{3}He + n. The probability of the 2^{3}He + n channel is significant, amounting to about 30 %.

The distribution of the events 2^{3}He and ^{3}He + ^{4}He over the excitation energy Q_{2He} defined as a difference of the invariant mass of the fragmenting system and the sum of the fragment masses is shown in Fig. 1. The values Q_{2H} of the channel ^{3}He + ^{4}He are distributed in the range covering the known levels of the ^{7}Be nucleus excitation.

One of the tasks of this study consisted in searching for narrow pairs 2^{3}He with values Q_{2^3He} in a range of 100–200 keV the indication to which was obtained for dissociation ^{9}C → 3^{3}He. The obtained distribution includes four events with values in the range of 200–400 keV (Fig. 3, dotted histogram in insertion). These data do not exclude a possible existence of the resonant state 2^{3}He discussed in [6].

There is an opportunity of ^{7}Be fragmentation via an unstable ^{6}Be nucleus with a threshold 1.37 MeV above ^{4}He + 2p. Figure 2 shows distribution of events ^{4}He + 2p over the difference of the invariant mass of the

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Table 1 Distribution over the dissociation channels of ^{7}Be nuclei for “white” stars N_{ws} and events with target fragments or produced mesons N_{tf}

Channel	^{2}He	He + ^{2}H	^{4}H	Li + H
N_{ws}	115	157	14	3
N_{tf}	154	226	–	–

Table 2 Distribution over the dissociation channels of ^{7}Be nuclei for “white” stars N_{ws} and events with target fragments or produced mesons N_{tf}

Channel	^{3}He + ^{4}He	^{3}He + ^{3}He
N_{ws}	32	14
N_{tf}	24	9

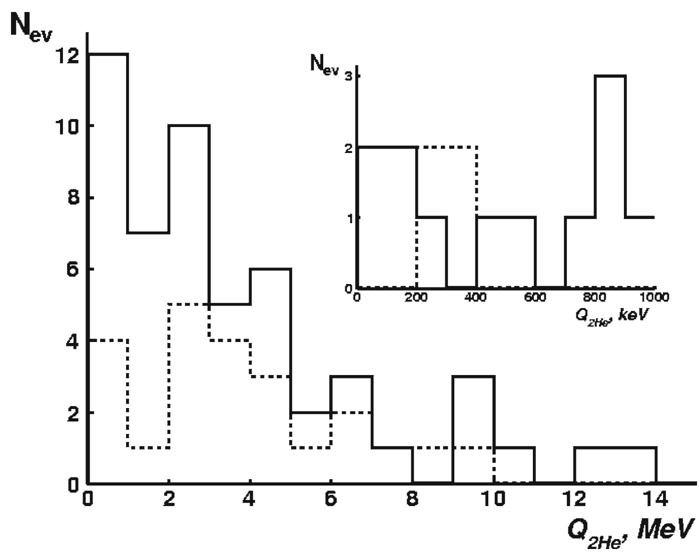

Fig. 1 Distribution of events distribution of events ^{7}Be→^{3}He + ^{4}He and 2^{3}He over the excitation energy Q_{2He} (*solid and dotted histograms*, respectively). Histograms for values $Q_{2He} < 1$ MeV are on the insertion and 2^{3}He over the excitation energy Q_{2He} (*solid and dotted histograms*, respectively). Histograms for values $Q_{2He} < 1$ MeV are on the *insertion*

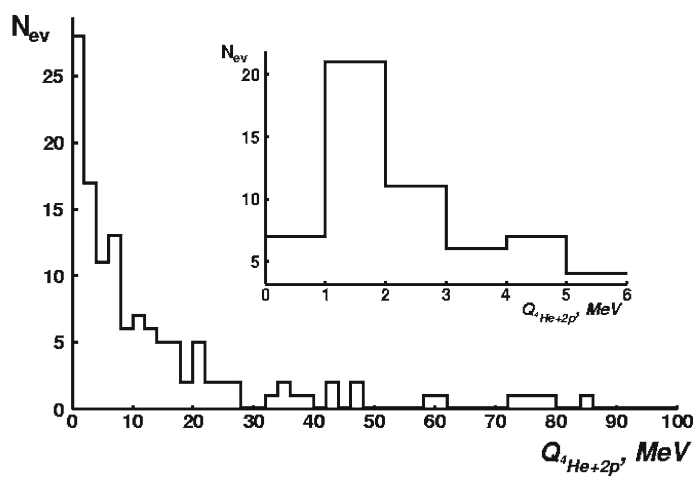

Fig. 2 Distribution of events ^{7}Be→^{4}He + 2p over the excitation energy $Q_{^4He+2p}$

produced α-particle and two protons and their mass sum $Q_{^4He+2p}$. The region $Q_{^4He+2p} < 6$ MeV indicates on the presence of about 27 % events ^{7}Be →^{6}Be →^{4}He + 2p. Thus, contribution of the configuration ^{6}Be + n to the ^{7}Be structure is estimated at a level of 8 ± 1 %.

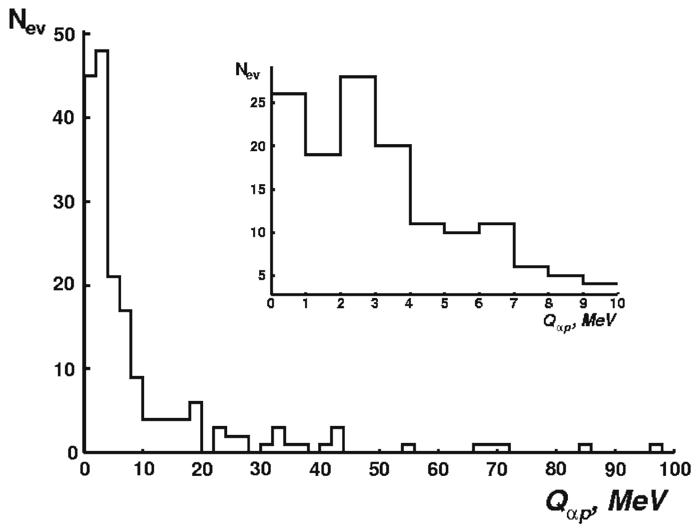

Fig. 3 Distribution of events ^{7}Be→^{4}He + 2p over the excitation energy $Q_{^4He+p}$ (events related to the ^{6}Be decays are excluded from this histogram)

The question about the contribution of the ^{5}Li resonance decaying to α + p with an energy of 1.69 MeV and width of 1.5 MeV has a significance independent of ^{6}Be since the production threshold of ^{5}Li + p is 0.35 MeV higher than the one of the ground state ^{6}Be. Despite of the absence of a clear signal the distribution $Q_{\alpha p}$ (Fig. 3) does not contradict to a possible contribution of ^{5}Li decays.

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