Light Nucleus Clustering in Fragmentation Above 1A GeV

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An overview of studies of cluster degrees of freedom in light stable and radioactive nuclei with an initial energy above 1A GeV in nuclear emulsions is given.

Fragmentation of relativistic nuclei provides an excellent laboratory to explore the transition of nuclei from the ground state to a gas-like phase composed of nucleons and few-nucleon clusters having no excited states, i. e. d, t, ^{3}He, and α. The research challenge is to find indications for the formation of quasi-stable or loosely bound systems significantly exceeding the sizes of the fragments. Search for such states on the nuclear scale is of undoubted interest since they can play a role of intermediate states ("waiting stations") for a stellar nuclear fusion due to dramatically reduced Coulomb repulsion. The fragmentation features might assist one to disclose the scenarios of few-body fusions as processes inverse to fragmentation.

The fragmentation of a large variety of light nuclei was investigated using the emulsions exposed to few A GeV nuclear beams at JINR [1 and ref. herein]. Thank to the best spatial resolution and the full solid angle acceptance provided by nuclear emulsions, such an approach allows one to obtain observations reflecting cluster-like features in decays of light nuclear structures. Images reflecting capabilities of emulsion technique of this can be found via the Web [2].

The common topological feature for fragmentation of the Ne, Mg, Si, and S nuclei consists in a suppression of binary splitting to fragments with charges larger than 2. The growth of the fragmentation degree is revealed in an increase of the multiplicity of singly and doubly charged fragments up to complete dissociation with increasing of excitation. This circumstance shows in an obvious way on a domination of the multiple cluster states having high density over the binary states having lower energy thresholds.

Formation of systems involving the α, d and t nuclei is being studied for a relativistic fragmentation of ^{6,7}Li, ^{10,11}B, ^{12}C, ^{14}N, and ^{16}O nuclei. ^{3}He clustering in ^{7}Be excitation is shown and the next round of tasks, as to whether this kind of nuclear clustering is revealed in heavier neutron-deficient nuclei, might be attacked.

In 2004, emulsion stacks were exposed to 2A GeV/c ^{9}Be, ^{8}B, and ^{9}C nuclei. The priority task is to establish the probability of $^9\text{C}\rightarrow 3^3\text{He}$ decays with respect to $^9\text{C}\rightarrow \text{p}^8\text{B}$, pp^{7}Be. The inverse 3^3He fusions might be similar to the 3α process with significantly higher energy output. It is suggested to form ^{10,11}C beams to explore the ^{3}He role in ^{10,11}C 3-body decays and to extent the 3He process.

[1] Bradnova, V. et al., Acta Physica Slovaca, 54, pp. 351-365, 2004.
[2] Web site of the BECQUEREL Project, http://becquerel.lhe.jinr.ru.