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SEARCH FOR ALPHA-CONDENSATE EFFECTS IN DISSOSIASION OF RELATIVISTIC NUCLEI

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The BECQUEREL experiment is aimed at solving topical problems in nuclear cluster physics [1]. Due to its unique sensitivity and spatial resolution the used method of nuclear track emulsion (NTE) makes it possible, to study in a unified approach multiple final states arising in the dissociation of relativistic nuclei. The focus is a concept of α-particle Bose-Einstein condensate (αBEC) - the extremely cold state of several S-wave α-particles near the coupling threshold. The unstable ^{8}Be nucleus is described as 2αBEC, and the ^{12}C(0_2^+) excitation or Hoyle state (HS) as 3αBEC. The state ^{16}O(0_6^+) above the 4α threshold, considered as 4αBEC, can sequentially decay ^{16}O(0_6^+) $\rightarrow \alpha^{12}$C(0_2^+) or ^{16}O(0_6^+) $\rightarrow 2^8$Be(0^+).

In NTE layers longitudinally exposed to relativistic nuclei the invariant mass of ensembles of He and H fragments can be determined from the emission angles in the approximation of conservation of initial momentum per nucleon. ^{8}Be and HS decays, as well as ^{9}B $\rightarrow$ ^{8}Bep decays, are identified in fragmentation of light nuclei by an upper constraint on the invariant mass [2]. Photos and videos of characteristic interactions are available on the site http://becquerel.jinr.ru/. This approach has been used to identify ^{8}Be and HS and search for more complex states of αBEC in fragmentation of medium and heavy nuclei. Recently, based on the statistics of dozens of ^{8}Be decays, an enhancement in the probability of detecting ^{8}Be in an event with an increase in the number of relativistic α-particles in it was found [3]. A preliminary conclusion is drawn that the contributions from ^{9}B and HS decays also increase. The exotically large sizes and lifetimes of ^{8}Be and HS suggest the possibility of synthesizing αBEC by successively connecting the emerging α-particles 2α $\rightarrow$ ^{8}Be, ^{8}Beα $\rightarrow$ ^{12}C(0_2^+), ^{12}C(0_2^+)α $\rightarrow$ ^{16}O(0_6^+), 2^{8}Be $\rightarrow$ ^{16}O(0_6^+) and further with a decreasing probability at each step, when γ-quanta or recoil particles are emitted. Nowadays, the main task is to clarify the relation between the appearance of ^{8}Be and HS and the multiplicity of α-ensembles and to search on this basis for decays of the ^{16}O(0_6^+) state. In this regard, the BECQUEREL experiment aims to measure multiple channels of ^{84}Kr fragmentation at energies up to 950 MeV per nucleon. There are a sufficient number of NTE layers, the transverse scanning of which on a motorized microscope makes it possible to achieve the required statistics. A status of the ongoing research is presented.

1. P.I. Zarubin, Lect. Notes in Phys. 875, Clusters in Nuclei, Volume 3. Springer Int. Publ., 51 (2013); DOI: 10.1007/978-3-319-01077-9_3, arXiv: 1309.4881.
2. D.A. Artemenkov et al., Eur. Phys. J. A 56 (2020) 250; DOI: 10.1140/epja/s10050-020-00252-3, arXiv: 2004.10277.
3. A.A. Zaitsev et al., Phys. Lett. B 820 (2021) 136460; DOI 10.1016/j.physletb.2021.136460, arXiv: 2102.09541.

Section

1. Nuclear structure: theory and experiment

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