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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 (α BEC) - the extremely cold state of several S-wave α -particles near the coupling threshold. The unstable ⁸Be nucleus is described as 2α BEC, and the ¹²C(0₂⁺) excitation or Hoyle state (HS) as 3α BEC. The state ¹⁶O(0₆⁺) above the 4 α threshold, considered as 4α BEC, can sequentially decay ¹⁶O(0₆⁺) $\rightarrow \alpha^{12}$ C(0₂⁺) or ¹⁶O(0₆⁺) $\rightarrow 2^{8}$ 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. ⁸Be 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 ⁸Be and HS and search for more complex states of α BEC in fragmentation of medium and heavy nuclei. Recently, based on the statistics of dozens of ⁸Be decays, an enhancement in the probability of detecting ⁸Be 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 ⁹B and HS decays also increase. The exotically large sizes and lifetimes of ⁸Be and HS suggest the possibility of synthesizing α BEC by successively connecting the emerging α -particles $2\alpha \rightarrow {}^{8}$ Be, 8 Be α $\rightarrow {}^{12}C(0_2^+), {}^{12}C(0_2^+)\alpha \rightarrow {}^{16}O(0_6^+), 2^8Be \rightarrow {}^{16}O(0_6^+)$ 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 ⁸Be and HS and the multiplicity of α -ensembles and to search on this basis for decays of the ¹⁶O(0⁺₆) state. In this regard, the BECQUEREL experiment aims to measure multiple channels of ⁸⁴Kr 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.

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- D.A. Artemenkov et al., Eur. Phys. J. A 56 (2020) 250; DOI: 10.1140/epja/s10050-020-00252-3, arXiv: 2004.10277.
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Section

1. Nuclear structure: theory and experiment

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