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Unstable nuclei 8Be and 9B and the Hoyle state in relativistic nuclear fragmentation

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The BECQUEREL experiment is aimed at solving topical problems in nuclear clustering physics. The used method of nuclear track emulsion (NTE) makes it possible, due to its unique sensitivity and spatial resolution, to study in a unified approach multiple final states arising in dissociation of relativistic nuclei. Currently, a research focus is on the theoretical concept of α-particle Bose-Einstein condensate (αBEC) - the ultra cold state of several S-wave α-particles near coupling thresholds. The unstable 8Be nucleus is described as 2αBEC, and the 12C(0+2) excitation or Hoyle state (HS) as 3αBEC. Decays 8Be ⟶ 2α and 12C(0+2) ⟶ 8Beα can serve as signatures for more complex αBEC decays. Thus, the 0+6 state of the 16O nucleus at 660 keV above the 4α threshold, considered as 4αBEC, can sequentially decay 16O(0+6) ⟶ α12C(0+2) or 16O(0+6) ⟶ 28Be(0+).
The consideration of αBEC as an invariant phenomenon indicates possibility of its search in the relativistic fragmentation. A practical alternative is provided by NTE layers longitudinally exposed to relativistic nuclei. The invariant mass of ensembles of He and H fragments can be determined from emission angles in the approximation of conservation of momentum per nucleon of a parent nucleus. Owing to extremely small energies and widths, the 8Be and HS decays, as well as 9B ⟶ 8Bep, are identified in fragmentation of light nuclei by an upper constraint on the invariant mass.
Having been tested, this approach has been used to identify 8Be 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 8Be decays, an enhancement in probability of detecting 8Be in an event with an increase in number of relativistic α-particles was found. A preliminary conclusion is drawn that contributions of 9B and HS decays also increase. The exotically large sizes and lifetimes of 8Be and HS allowing suggesting possibility of synthesizing αBEC by successively connecting the emerging α-particles.The main task of the forthcoming stage of the project is to clarify the relation between the appearance of 8Be and HS and α-ensemble multiplicities and search on this basis for decays of the 16O(0+6) state. Currently, the BECQUEREL experiment aims to measure multiple channels of 84Kr fragmentation below 1 GeV per nucleon. Searches for αBEC lead to the study of nuclear matter with temperature and density ranging from red giants to supernovae. In this respect NTE layers exposed to heavy nuclei at several GeV per nucleon of the NICA accelerator complex will make it possible to study relativistic ensembles of H and He isotopes of unprecedented multiplicity under optimal conditions.
[1] P.I. Zarubin, Lect. Notes in Phys. 875, Clusters in Nuclei, Volume 3. Springer Int. Publ., 51 (2013); arXiv: 1309.4881
[2] D.A. Artemenkov et al., Eur. Phys. J. A 56 (2020) 250; arXiv: 2004.10277
[3] A.A. Zaitsev et al., Phys. Lett. B 820 (2021) 136460; arXiv: 2102.09541
[4] D.A. Artemenkov et al., Phys. At. Nucl. 85, 528 (2022); arXiv: 2206.096

Section

Nuclear structure: theory and experiment

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