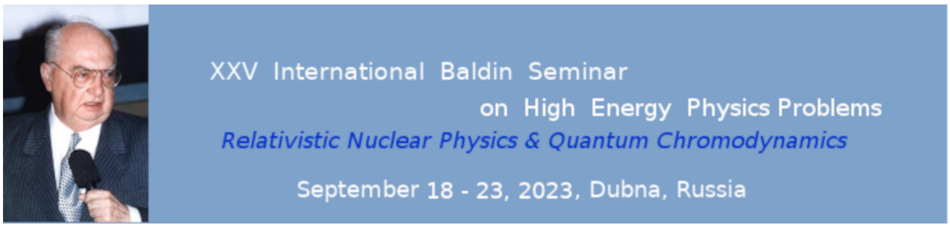

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Overview of unstable states studies in fragmentation of relativistic nuclei

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Starting with the discovery of the nuclear component of cosmic rays, the nuclear track emulsion method (NTE) makes an opportunity to study the composition of the relativistic fragmentation of nuclei at high-energy accelerators. The promising potential of the relativistic approach to the analysis of ensembles of fragments was manifested in NTE exposed by nuclei at several GeV per nucleon accelerated at the JINR Synchrophasotron and Bevalac (USA) in the 1970s. Since the 2000s of the NTE method is applied in the BECQUEREL experiment at the JINR Nuclotron in respect to the cluster structure of nuclei, including radioactive ones, as well as the search for unstable nuclear-molecular states. Due to its unique sensitivity and spatial resolution the used NTE method gives an opportunity to study in a unified approach multiple final states arising in the dissociation of relativistic nuclei. The aims to search in the relativistic approach for the α-particle Bose-Einstein condensate (αBEC), an unstable state of S-wave α-particles. The extremely short-lived ^{8}Be nucleus is described as 2αBEC, and the ^{12}C(0_2^+) excitation or Hoyle state (HS) as 3αBEC. The realizability of more complex states is essential in nuclear astrophysics.
Using NTE layers exposed longitudinally to relativistic nuclei the invariant mass of ensembles of He and H fragments can be determined over the emission angles in the approximation of conservation of initial momentum per nucleon. The ^{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 [1]. 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 increase in the probability of detecting ^{8}Be with an increase in the number of associated α-particles $n\alpha$ was found [2]. 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. Ongoing investigation aims to measure $n\alpha$ channels of ^{84}Kr fragmentation at energies up to 950 MeV per nucleon to determine the contributions of 2α decays of ^{8}Be, the Hoyle 3α state, and the search for a 4α particle condensate state [3].

References

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