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Alpha-particle states in relativistic nuclear fragmentation

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Ensembles of He and H isotopes can be studied with unique completeness and resolution in nuclear emulsion layers longitudinally exposed to relativistic nuclei [1,2]. Determination of the invariant mass of their pairs or triplets by emission angles in the velocity conservation approximation is sufficient to identify a number of unstable states – ^{8}Be(0^{+}), ^{8}Be(2^{+}), ^{9}B, ^{12}C(0^{+}_{2}), ^{12}C(3^{-}), ^{6}Be.

The BECQUEREL experiment [3,4], using this approach, is aimed at searching for the α-particle Bose-Einstein condensate (αBEC), an unstable of S-wave α-particle state. ^{8}Be(0^{+}) is associated with 2αBEC, and ^{12}C(0^{+}_{2}) or the Hoyle state with 3αBEC. In the relativistic fragmentation of heavy nuclei, an enhancement of ^{8}Be, ^{9}B and ^{12}C(0^{+}_{2}) is detected, suggesting their synthesis in the fusion of associated α-particles. The focus of the search is the 4αBEC state of ^{16}O(0^{+}_{6}) at 660 keV above the 4α threshold, decaying into α^{12}C(0^{+}_{2}) or 2^{8}Be. In this context, the status of the analysis of α-particle fragmentation in a nuclear emulsion exposed to ^{84}Kr nuclei at 950 MeV per nucleon is presented. Secondary stars produced by relativistic neutrons are observed in the nucleus fragmentation cone [4]. The neutron average energy in the parent nucleus system is estimated to be 1.3 MeV [5].

The αBEC search leads to the study of nuclear matter in the region of temperature and density from red giants to supernova. It is characterized by the ratios of ^{1,2,3}H and ^{3,4}He. Nuclear emulsion layers exposed to heavy nuclei of several GeV per nucleon at the NICA accelerator complex are optimal for identifying H and He isotopes by multiple scattering, searching for unstable states, and assessing neutron accompaniment. An exposure to ^{124}Xe nuclei of 3.8 GeV per nucleon, performed at the NICA/Nuclotron accelerator complex, allows the use of proven approaches. Parameters of the beam are determined using the CR-39 track detector by direct crater counting on the Olympus BX63 microscope.

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Primary author(s) : ZARUBIN, Pavel (Joint Institute for Nuclear Research); ZAITSEV, Andrei

Presenter(s) : ZAITSEV, Andrei

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