Study of alpha-particle states in the fragmentation of relativistic nuclei
(The BECQUEREL Project http://becquerel.jinr.ru/)

Unstable states of ensembles of α-particles are studied by the methods of high energy physics. The formation of α-particles in nuclear reactions and decays indicates the presence in the nuclear structure of quartets of spin-paired protons and neutrons. The study of pairs of α-particles makes it possible to proceed to 2α-decays of the unstable ^{8}Be nucleus. According to the theory, α-particles in the ground state of ^{8}Be are separated by a distance of the order of their own size. This feature makes ^{8}Be a suitable trap in the 3α-process for the synthesis of the ^{12}C isotope via the Hoyle state (^{12}C(0^{+}_{2}) or HS). Not limited to the role of excitation of the ^{12}C nucleus, HS can also manifest itself in reactions with other nuclei, which combines it, like ^{8}Be, with other fragments. A larger α-particle numbers make it possible to search for their more complex analogs.

Effective generation of α-ensembles occurs in the region of the limiting fragmentation of relativistic nuclei, where the reaction thresholds become insignificant, but the spin structure of the initial state can be preserved. Only the nuclear track emulsion method (NTE) answers the challenges of detection and measurement in the projectile fragmentation cone. In NTE layers longitudinally irradiated by relativistic nuclei, the directions of tracks of fragments observed with exhaustive completeness are determined with a record resolution of 0.5 microns. Due to the minimum energy, the decays of ^{8}Be, ^{9}B, and HS should appear as pairs and triplets from relativistic He and H fragments with the smallest expansion angles. According to the widths, the decays of ^{8}Be, ^{9}B, and HS occur at ranges from several thousand (^{8}Be and HS) to several tens (^{9}B) atomic sizes and must be identified by the minimum invariant mass. While studying the relativistic fragmentation of a whole family of light nuclei, the authors identified the ^{8}Be → 2α 9B → ^{8}Be*p* and HS → ^{8}Beα decays determined from the emission angles of the fragments at the very beginning of the spectrum of invariant masses (of the order of 1 MeV), in the approximation of conservation of the velocity of the initial nucleus. Thus, on the basis of the invariant approach, a clear and universal possibility of studying α-unstable states is substantiated.

In development, the BECQUEREL project aims to measure α-particle channels of fragmentation in NTE of heavy relativistic nuclei. The objectives of the project are to clarify the relationship between the occurrence of ^{8}Be and HS and the multiplicity of α-ensembles and to search for the 4αBEC state on these statistics. To track the evolution and universality of the conclusions, the fragmentation of ^{28}Si nuclei at 3.65 GeV per nucleon into more than 5α particles is analyzed in the statistics of dozens of events. To solve these problems, there is a sufficient number of NTE layers. The search for events in them by transverse scanning on the microscope Olympus BX63 makes it possible to achieve the required statistics. Measurements in selected α-ensembles are carried out on the most precise KSM microscopes.

Papers in the http://becquerel.jinr.ru/text/indexin.html (choose English ones).

Fundamentals in http://becquerel.jinr.ru/text/books/POWELL.pdf (right click SAVE better)

Video collection in http://becquerel.jinr.ru/movies/movies.html

Good Luck!

Yours sincerely, Pavel Zarubin@jinr.ru.