Loosely Bound States in Heavy Ion Collisions

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Abstract

The binding energy of the deuteron, the simplest bound state of a proton and a neutron, is 2.2 MeV, that is about 10^6 times larger than the energy of the first level of the hydrogen atom (13.6 eV). Atomic nuclei are tightly bound objects if compared to atoms or molecules. However, when produced in high-energy heavy-ion collisions, the deuteron and other light nuclei appear as loosely bound objects, because their binding energy is small compared to the average kinetic energy of the particles produced in the collision. An even more “fragile" object is the hypertriton, where a Λ hyperon is bound to a proton and a neutron with a separation energy of only 130 keV. In addition, the size of composite objects as (hyper-)nuclei is comparable to a fraction or the whole system created in the collision. Having in mind these properties, nuclei and hypernuclei are studied in high-energy nucleus-nucleus reactions to understand their production mechanisms and access unique information to characterise the system produced in the collision.

Models of coalescence and thermal-statistical production, typically used to describe the formation of (hyper-)nuclei and other loosely bound objects, will be contrasted and discussed in the light of the most recent experimental findings by the ALICE Collaboration at the Large Hadron Collider (LHC). Results include the production of deuteron, triton, ^{3}He, ^{4}He and hypertriton, and their anti-matter counterparts. Crucial to this study are measurements of the production of A = 3 and A = 4 (anti-)(hyper-)nuclei that differ by mass, spin and size, as a function of the size of the particle-emitting source. The hypertriton appears as the particle with the strongest sensitivity to the production mechanism, but data are still scarce. In this respect, the study of loosely bound states in heavy-ion collisions will greatly profit from the increase in integrated luminosity foreseen for the High-Luminosity phase of the LHC in the next decade.