Light (anti-)nuclei production and flow in relativistic heavy-ion collisions

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We have studied the production of light normal and hyper nuclei and their anti-nuclei in heavy ion collisions at the LHC by using the coalescence model [1]. With the phase-space distributions of protons, neutrons, and Lambdas as well as their antiparticles at freeze out taken from the AMPT model [2] and taking the Wigner functions of these nuclei to be of Gaussian form with their width parameters fitted to the known radii, we have calculated the transverse momentum spectra and elliptic flows of ^{2}H-like nuclei that include ^{2}H and anti-^{2}H, of ^{3}H-like nuclei that include ^{3}H, ^{3}He, anti-^{3}H, and anti-^{3}He, and of $^3_\Lambda$H-like nuclei that include $^3_\Lambda$H, $^3_\Lambda$He, $^3_\Lambda$n, anti-$^3_\Lambda$H, anti-$^3_\Lambda$He, and anti-$^3_\Lambda$n.

For the transverse momentum spectra, we have found that the default version of the AMPT model gives a better description of the experimental data from the ALICE Collaboration [3,4] for proton and deuteron than the string-melting version of the AMPT model as shown in Fig. 1, and this has been attributed to the baryon problem in the current string-melting version of the AMPT code. From the total yield of these nuclei, we have verified the experimental observation that the yield of light nuclei is reduced by about two orders of magnitude with the addition of a nucleon or Lambda to a nucleus.

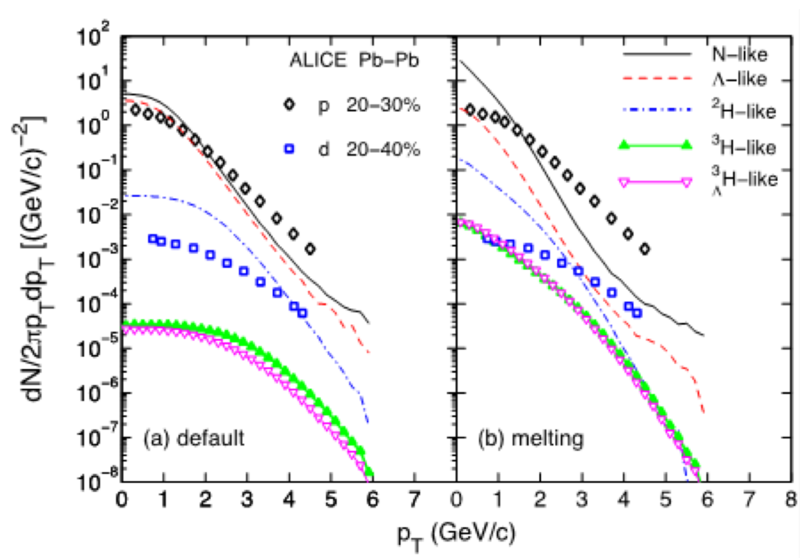

FIG 1. Transverse momentum spectra of N-like (solid line), Λ-like (dashed line), and ^{2}H-like (dash-dotted line), ^{3}H-like (filled triangles), $^3_\Lambda$H-like (open triangles) at midrapidity $|y| \leq 0.5$ from the default (left panel) and the string melting (right panel) AMPT model for Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV and impact parameter b = 8 fm. Data for protons (open diamonds) and deuterons (open squares) are from the ALICE Collaboration [3,4].

For the elliptic flows of these nuclei shown in Fig. 2, they are found to show a mass ordering behavior with the heavy nuclei having a smaller elliptic flow, like that in the hydrodynamic description of heavy ion collisions. This behavior is seen in both the default and the string melting AMPT model. We have further found that the elliptic flows of light nuclei display an approximate constituent number scaling in that their elliptic flows at transverse momentum per constituent is the same as a function of the transverse momentum divided by the number of constituents, particularly in the case of the default AMPT model.

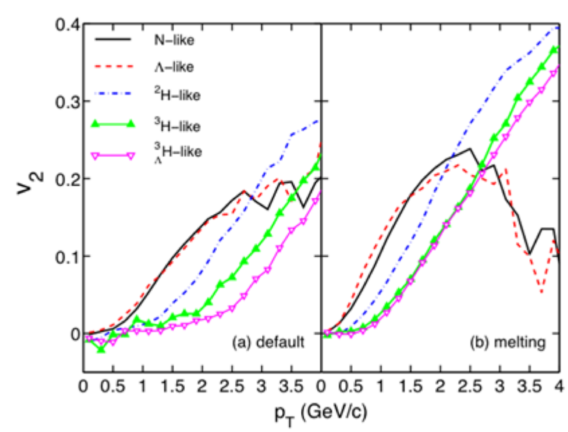

FIG 2. Elliptic flows of N-like (solid line), Λ-like (dashed line), and ^{2}H-like (dash-dotted line), ^{3}H-like (filled triangles), $^3{}_\Lambda$H-like (open triangles) at midrapidity $|y| \leq 0.5$ from the default (left panel) and the string melting (right panel) AMPT model for Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV and impact parameter b = 8 fm.

We have further studied the coalescence parameter B_A for light nuclei, which is defined by the ratio of the invariant transverse momentum spectrum of a nucleus to that of its constituents being raised to the power corresponding to the number of constituents in the nucleus. Our results based on both the default and string melting AMPT models indicate that the coalescence parameter increases with increasing transverse momentum of a nucleus, similar to that extracted from the experimental data. Their values are, however, a factor of two larger for B_2 and a factor of two smaller for B_3 in the case of the default AMPT model. In the string-melting version of the AMPT model, the value of B_2 is almost an order of magnitude larger than data at high momentum, but that of B_3 agrees with the data.

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[4] J. Adam *et al*. (ALICE Collaboration), Phys. Lett. B **754**, 360 (2016).