Formation of hypermatter and hypernuclei within transport models in relativistic ion collisions

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The investigation of hypernuclei is a rapidly progressing field of nuclear physics, since they provide complementary methods to improve traditional nuclear studies and open new horizons for studying particle physics and nuclear astrophysics. Relativistic ion collisions allow the production of exotic light hypernuclei, heavy hypernuclei, hypernuclear matter at subnuclear densities, and new experimental methods can be implemented beyond the traditional hypernuclear experiments with hadrons.

We use the Ultra-relativistic Quantum Molecular Dynamics (UrQMD) and Hadron-String Dynamics (HSD) models for description of the strangeness production. The interaction of hyperons with nucleons leads to their capture and to the formation of hyper-matter. We describe this process within a generalized coalescence model (CB). The coalescence of baryons is consistent with the hyperon capture in a potential well of large nuclear residues, and the coalescence parameter are expected to be of the same order as for normal fragments. Thus, this procedure gives a possibility to treat the formation of light hypernuclei on the same footing. As an example, Fig. 1 shows the rapidity distributions of light hypernuclei for a coalescence parameter $v_c = 0.22c$ [1]. The light ${}^{3}_{\Lambda}$H nuclei are essentially formed over all rapidities. On the other hand, larger hyperfragments are mostly produced within the spectator region.

With increasing energy the fraction of nuclei around residues increases, since more particles are produced in this region as a result of secondary interactions. Whereas particles originating from midrapidity have higher energy and they are more separated in the phase space. Therefore, despite of an increase of the number of such particles, the total number of clusters may not increase with beam energy. In Figure 2 we show the yields of all hyper-fragments, and also the yields of residues of projectiles and targets with captured hyperons, in relativistic carbon on carbon collisions. Indeed, the production of hypernuclei in such collisions is universal above the threshold (∼1.6 A GeV). The saturation of the yields of hypernuclei means that this kind of reactions can be studied at the accelerators of moderate relativistic energies, e.g., at GSI/FAIR.

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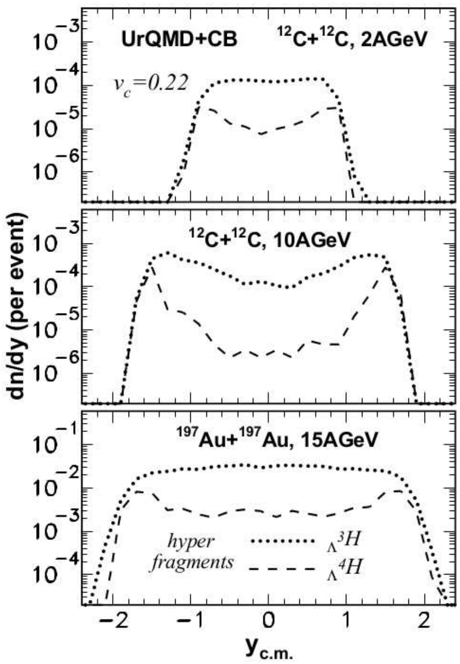

Figure 1: Rapidity distributions of produced ${}^{3}_{\Lambda}$H (dotted lines) and ${}^{4}_{\Lambda}$H (dashed lines) hyper-fragments. The UrQMD and CB calculations are with the coalescent parameter $v_c = 0.22c$ [1].

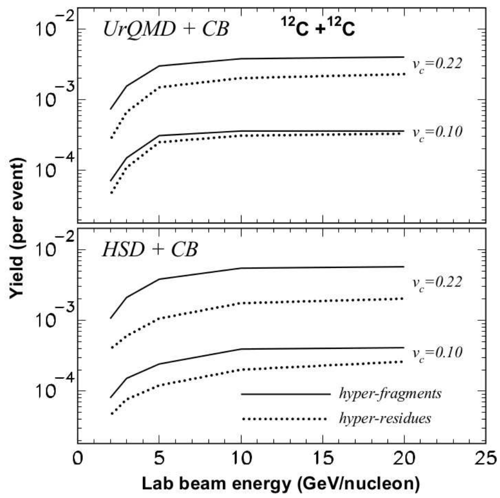

Figure 2: Yields of all produced hyper-fragments (solid lines) and hyper-residues (dotted lines) versus the beam energy in carbon on carbon collisions for realistic coalescence parameters.

References

[1] A.S. Botvina, J. Steinheimer, E. Bratkovskaya, M. Bleicher, J. Pochodzalla, Phys. Lett. B742 , p.7-14 (2015).

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