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HYPERNUCLEI PRODUCTION IN HEAVY ION COLLISIONS WITHIN A THERMAL MODEL APPROACH*

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We present theoretical estimates of the expected ratios of yields of hypernuclei and antihypernuclei in Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV within the framework of a thermal model. This model can successfully reproduce the ratios of other hadrons produced in heavy ion collisions at RHIC energy. The prediction are compared to recent data of the STAR experiment at RHIC, aiming to elucidate the production mechanism of hypernuclei and antihypernuclei in heavy ion collisions at RHIC.

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1. Introduction

Since the first observation of hypernuclei in 1952 [1] there has being a steady interest in searching for new hypernuclei and exploring the hyperon–nucleon interaction which is of great importance for nuclear physics and nuclear astrophysics, *e.g.* for the physics of neutron stars. Hypernuclei are nuclei which contain at least one hyperon. Free hypernuclei decay with lifetime

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which depends on the strength of the hyperon–nucleon interaction. While several hypernuclei have been discovered since 1952, no antihypernucleus has ever been observed until the recent discovery of the antihypertriton in Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV by the STAR experiment at RHIC [2].

Experiments measuring the final state from heavy ion collisions at ultra-relativistic energies aim to reproduce and study one of the phase transitions believed to have happened in the early universe 10^{-6} s after the Big Bang, namely the phase transition between hadronic matter and deconfined quark and gluon matter. There is today evidence [3] that a high density partonic source is build in the initial state of the heavy ion collisions at RHIC, which is strongly interacting. This state is noted in short as sQGP: strongly interacting Quark Gluon Plasma.

The yield of (anti)hypernuclei measured by STAR is very large, in particular they seem to be produced with similar yield as (anti)nuclei in particular (anti)helium-3. This abundance is much higher than measured for hypernuclei and nuclei found at lower energies. It therefore appears that RHIC is particularly suited to produce abundantly (anti)hypernuclei. It follows a strong interest to understand the nature of this enhanced abundance, and for this the mechanism of production of (anti)hypernuclei should be investigated.

It has been found that ratios of hadrons produced in heavy ion collisions can be described by thermal models [4–6]. These studies allow to estimate thermal characteristics of the particle source at the chemical freeze out, after which ratios of particles remain constant.

In this paper we estimate ratios of hypernuclei and antihypernuclei production in Au + Au collisions at RHIC using a thermal model. We compare these predictions with the data from the STAR Collaboration, aiming to elucidate the production mechanism of hypernuclei and antihypernuclei in heavy ion collisions at RHIC.

2. Thermal model calculations for (anti)hypernuclei at RHIC

In order to estimate hypernuclei and antihypernuclei yields we use a thermal model in the grand-canonical approach. We fix the thermal parameters to the values which have been previously found to best describe hadron production in Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV. In particular, we use a temperature T of 170 MeV and a baryochemical potential of $\mu_B = 23.5$ MeV [6]. The feeding of (anti)helium-3 from (anti)hypertriton decay is corrected in the data assuming a branching ratio of 25% for the decay of (anti)hypertriton to (anti)helium-3 and pion, and it has been taken into account in the model calculation.

Figure 1 shows the ratios of antiproton to proton, of antihypertriton to hypertriton, of antihelium-3 to helium-3, of antihypertriton to antihelium-3 as well as of hypertriton to helium-3 in Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV. The black circles show these ratios as measured by the STAR Collaboration in Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV [2, 7, 8]. The grey (red) circles show the model results for those ratios.

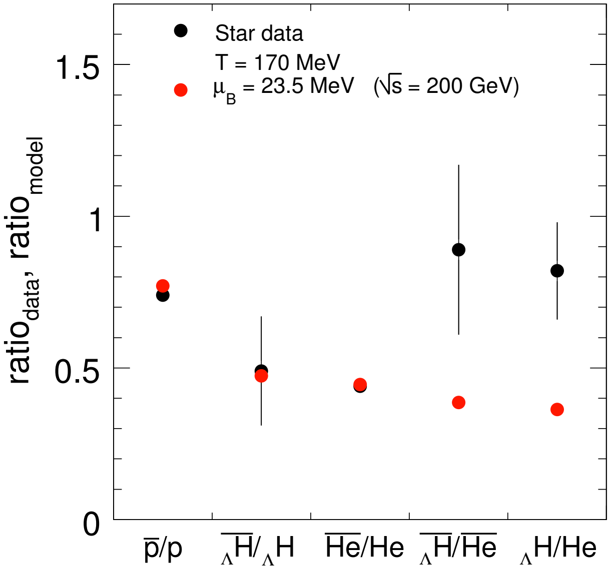

Fig. 1. Ratios of antiproton to proton, of antihypertriton to hypertriton, of antihelium-3 to helium-3, of antihypertriton to antihelium-3 as well as of hypertriton to helium-3 in Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV. The black circles show these ratios as measured by the STAR Collaboration in Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV [2, 7, 8]. The grey (red) circles show the model results for those ratios in this work.

It is demonstrated that while the thermal prediction agrees with the data for all antiparticle to particle ratios namely of antiproton to proton, of antihypertriton to hypertriton, of antihelium-3 to helium-3, it deviates in the cases of ratios between the (anti)hypernuclei and the (anti)helium-3. The model prediction which is about 0.4 for the antihypertriton to antihelium-3 and the hypertriton to helium-3 ratios falls below the measured ratios reaching a value near 1. One has to take into account that the experimental errors are quite large.

3. Summary and outlook

We have presented the ratios of antiproton to proton, antihypertriton to hypertriton, antihelium-3 to helium-3, antihypertriton to antihelium-3 as well as of hypertriton to helium-3 in Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV estimated with a thermal model and using temperature and chemical potential found previously to describe well the overall hadron ratios in these collisions. We have compared the model estimates to the same ratios measured by the STAR Collaboration [2] and found a good description for antiparticle to particle ratios. The (anti)hypertriton to (anti)helium-3 ratios in the model underestimate those measured by STAR.

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