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Hypertriton and exotic bound states production in Pb-Pb collisions at the LHC with the ALICE experiment

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Summary. — The ALICE Collaboration has studied the production of (anti-) hypertriton, ${}^{3}_{\Lambda}\mathrm{H}$, and the exotic bound states, H-dibaryon and $\overline{\Lambda n}$, in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76\,\mathrm{TeV}$. The data sample has been collected during the LHC heavy-ion run at the end of 2011. The ${}^{3}_{\Lambda}\mathrm{H}$ has been studied via its two-body mesonic weak decay (${}^{3}_{\Lambda}\mathrm{H} \rightarrow {}^{3}\mathrm{He} + \pi^{-}$), while the H-dibaryon and $\overline{\Lambda n}$ through their Λ+p+π^{-} and $\overline{d}$+π^{+} final states, respectively.

1. – Introduction

Heavy-ion collisions at LHC energies provide a unique opportunity to understand the nature of the medium (*Quark-Gluon Plasma*) created during the collision. In heavy-ion collisions many strange hadrons are produced and hyperon-baryon bound systems can be formed. There are two distinct approaches used to estimate the production yield of these systems: thermal model [1] and coalescence model [2].

H-dibaryon and Λn bound state discovery would provide crucial information on the Λ-*nucleon* and Λ-Λ interaction.

2. – Hypertriton

The hypertriton ${}^{3}_{\Lambda}\mathrm{H}$ is the lightest known hypernucleus and consists of a proton, a neutron and a Λ. Its mass is 2.991 ± 0.002 GeV/c^2 and its lifetime is expected to be compatible with the free Λ lifetime. The ${}^{3}_{\Lambda}\mathrm{H}$ and ${}^{3}_{\overline{\Lambda}}\overline{\mathrm{H}}$ production yield were measured through their mesonic weak decay. Topological cuts were applied for the identification of secondary vertices and the production yield was extracted from the invariant-mass distributions of (${}^{3}\mathrm{He}$+π^{-}) and (${}^{3}\overline{\mathrm{He}} + \pi^{+}$) pairs.

In the left panel of fig. 1 the measured production yield $\mathrm{d}N/\mathrm{d}y \times$ BR of ${}^{3}_{\Lambda}\mathrm{H}$ is compared to different theoretical models as a function of the branching ratio (BR) of the two-body decay channel. Assuming a theoretical BR = 25% [3], the models in agreement

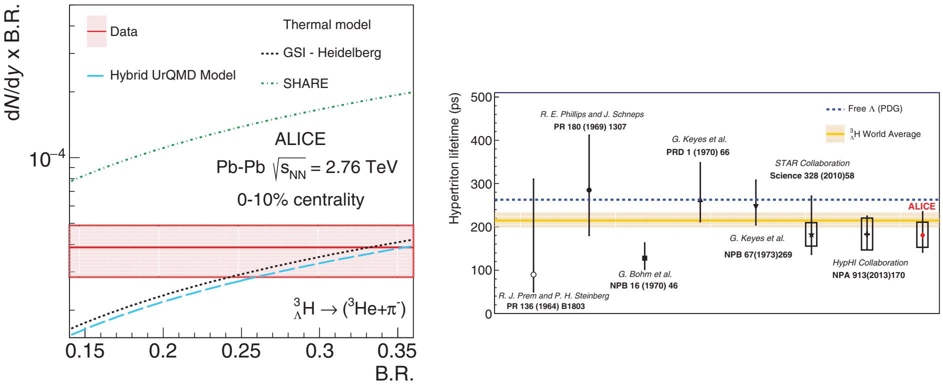

Fig. 1. – Left: $\mathrm{d}N/\mathrm{d}y$ comparison to different models for the $^{3}_{\Lambda}$H measurement. Right: $^{3}_{\Lambda}$H lifetime (τ) measured by the ALICE Collaboration compared to the published results.

with the measured yield are the equilibrium statistical model (GSI-Heidelberg [1]), with a temperature $T_{chem} = 156\,\mathrm{MeV}$, and the Hybrid UrQMD model [2], which combines the hadronic transport approach with an initial hydrodynamical stage for the hot dense phase.

The total sample of $^{3}_{\Lambda}$H and $^{3}_{\overline{\Lambda}}\overline{\mathrm{H}}$ has been divided into four intervals of $ct = MLc/p$. M is the mass and it has been fixed to $2.991\,\mathrm{GeV}/c^2$, L is the decay length, c is the speed of light and p is the particle momentum. An exponential fit to the $\mathrm{d}N/\mathrm{d}(ct)$ distribution was performed to determine the proper decay length, which is $c\tau = 5.4^{+1.6}_{-1.2}$ (stat.) $\pm\,1.0$ (syst.)cm. In the right panel of fig. 1 the lifetime measured by ALICE, $\tau = 181^{+54}_{-39}$ (stat.) $\pm\,33$ (syst.) ps, is contrasted with the free Λ lifetime and with previous measurements of the hypertriton lifetime. The orange band shows the statistical combination of the experimental lifetime estimates available which leads to $\tau = 216^{+19}_{-18}$ ps [4], in agreement with ALICE measurement.

3. – Exotic bound states

The H-dibaryon is a hypothetical *uuddss* bound state ($\Lambda\Lambda$) first predicted by Jaffe [5] using a bag model approach. In this analysis the $\Lambda p\pi^-$ decay channel of the H-dibaryon was investigated, under the assumption of a weakly-bound state. Since no evidence of a signal for the H-dibaryon was found in the invariant mass distribution, an upper limit (99% CL) of $\mathrm{d}N/\mathrm{d}y$ was obtained, assuming a BR = 64% and the free Λ lifetime. The limit $\sim 3.0 \times 10^{-4}$ is a factor 20 below values predicted by the thermal models ($\mathrm{d}N/\mathrm{d}y \approx 6 \times 10^{-3}$).

The $\overline{\Lambda n}$ bound state was investigated in the decay $\overline{\mathrm{d}}\pi^+$, but no signal was found in the invariant mass distribution. Assuming a BR = 54% and the free Λ lifetime, this led to an upper limit (99% CL) of $\mathrm{d}N/\mathrm{d}y \sim 2.0\times10^{-3}$ that is a factor 20 below values predicted by thermal models ($\mathrm{d}N/\mathrm{d}y \approx 4 \times 10^{-2}$).

A detailed description of the results on the hypertriton and the exotic bound states can be found in [6] and [7].

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