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Study of the production of light (anti-)nuclei with the ALICE experiment at the LHC

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Summary. — The ALICE Collaboration has measured the production of light (anti-)nuclei in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV}$ at the LHC. In particular, this article will focus on the measurement of the (anti-)deuteron elliptic flow. The measurements are compared with the predictions by different theoretical approaches.

1. – Introduction

In the high-energy heavy-ion collisions at the LHC, an abundant production of light nuclei and anti-nuclei is observed, albeit their binding energy is much lower than the temperature of the system at chemical freeze-out, at which the abundances of the particle species are fixed. Therefore, the comparison of the production yields with theoretical predictions is important to understand the mechanisms of production of light (anti-)nuclei. In particular, two different production models are considered: the statistical thermal model [1] and the coalescence approach [2]. According to the thermal model, the nuclei are thermally produced in the expanding fireball together with the other hadron species. For the coalescence model, instead, nucleons which are close to each other in phase space coalesce to form a light nucleus.

2. – Elliptic flow

The elliptic flow is a collective motion effect related to the initial geometry of the collision. Heavy ions are extended objects and the dimensions and the shape of the overlap region of the colliding nuclei in the transverse plane depends on the impact parameter, *i.e.*, the distance between the centres of the two. The initial geometrical asymmetry causes a momentum anisotropy, which results in an anisotropy in the angular distribution of the particles. The angular distribution can be expanded in a Fourier

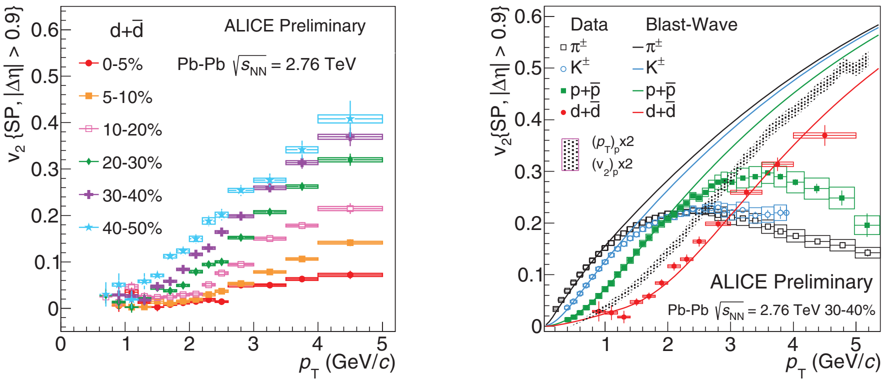

Fig. 1. – *Left*: v_2 as a function of p_T for different centrality intervals. In both the panels particles and anti-particles are summed. *Right*: v_2 as a function of p_T for π/K/p and d with the Blast-Wave expectation in 30–40% centrality class. The magenta band is the prediction for the simple coalescence production of d.

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$$\frac{\mathrm{d}N}{\mathrm{d}(\phi - \Psi_{RP})} = \frac{N_0}{2\pi}\left(1 + \sum_{n=1}^{\infty} 2v_n \cos[n(\phi - \Psi_{RP})]\right), \tag{1}$$

where ϕ is the angle of the considered particle and Ψ_{RP} is the angle of the reaction plane, which is defined by the impact parameter and the flight direction of the colliding nuclei. The coefficient $v_2 = \langle \cos 2\,(\phi - \Psi_{RP}) \rangle$ is used to quantify the ellipticity of the particle production and hence to characterise the initial fireball anisotropy. Its value is hence driven by the initial fireball anisotropy, but it is also found to be sensitive to the production mechanism. For a particle produced in a fireball in local thermal equilibrium, the v_2 as a function of the transverse momentum (p_T) is well reproduced by the blast-wave hydrodynamical model [3]. In contrast to this, in a simple coalescence model, which assumes an uncorrelated particle production in a static non-expanding source, the v_2 of the deuteron is expected to be equal to the sum of the v_2 of the two coalescing nucleons at the sum of their momenta.

3. – Results

In fig. 1 the v_2 of the deuteron and other particle species is reported. For these measurements, the v_2 has been computed using the scalar product method [4]. In the left panel, one can see the v_2 of the deuteron and its anti-particle as a function of p_T for several centrality classes. The v_2 increases from central to peripheral events, reflecting the initial geometrical asymmetry of the collision. The right panel, instead, shows the v_2 for different species in the 30–40% centrality class. The data at low transverse momentum are correctly reproduced by a blast wave model for all the particle species. In particular, for deuterons and anti-deuterons (red dots) the data are correctly reproduced up to large values of p_T. On the other hand, the simple coalescence model is not able to correctly reproduce the data, suggesting a different mechanism for the production of light (anti-)nuclei.

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