Studying the dependence of transverse spherocity on the initial and final state anisotropies in heavy-ion collisions

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Introduction

In non-central heavy-ion collisions, the overlap region of the colliding nuclei is oval-shaped and possesses event-by-event fluctuation in the nucleon density distribution. These initial profiles for initial nucleon distribution are quantified by eccentricity (ε_2) and triangularity (ε_3). For a hydrodynamically evolving system, if the pressure gradient formed during the collision of the nuclei is large enough, initial spatial eccentricities can be transformed into final state momentum space azimuthal anisotropies, quantified by the coefficients of the Fourier expansion of the invariant yield, *viz.,* elliptic flow (v_2) and triangular flow (v_3).

On the other hand, transverse spherocity (S_0), an event shape observable, is known for its excellent capability for separating the jetty events dominated by the hard interactions from the isotropic events dominated by the soft-QCD interactions. Recent studies show that the event selection based on S_0 can achieve higher radial flow velocity and lower kinetic freezeout temperatures compared to when no S_0 selection is made [1]. Here, we use transverse spherocity as an event classifier to see its dependence on ε_2, ε_2, v_2 and v_3 in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV using a multi-phase transport model (AMPT). In this study, the centrality selection is performed using geometrical impact parameter slicing. For each centrality class, 20% events having the highest and lowest S_0 values are termed as high-S_0 and low-S_0, respectively [2].

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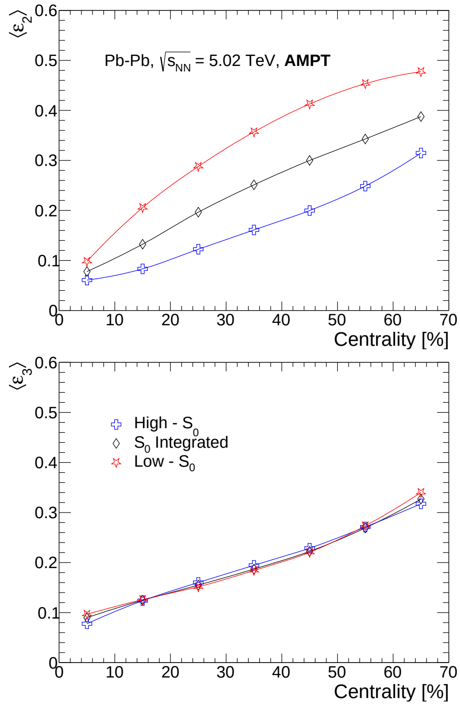

FIG. 1: Eccentricity (ε_2) and triangularity (ε_3) versus centrality for different transverse spherocity selections in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV using AMPT [2].

Results and Discussions

Figure 1 shows ε_2 and ε_3 as a function of collision centrality and transverse spherocity in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV using AMPT. Both ε_2 and ε_3 gradually increase as one moves from the central to the peripheral collisions as the collision overlap region gets more anisotropic. Additionally, ε_2 shows reasonable dependence on S_0, while ε_3 is independent of S_0 selection as it is caused by event-by-event density fluctuations and, in principle,

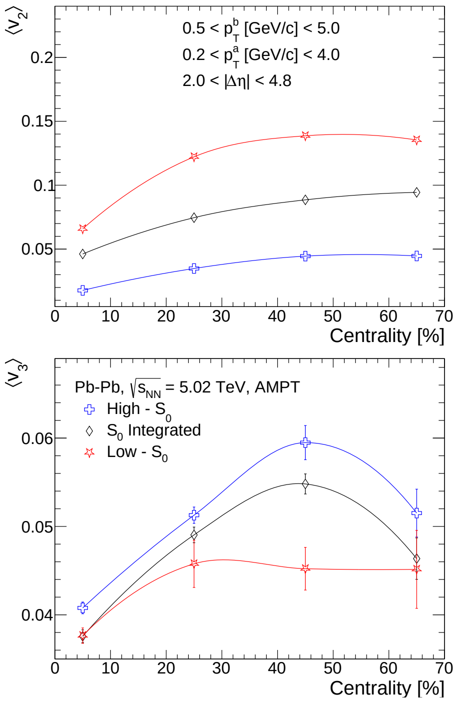

FIG. 2: Elliptic flow (v_2) and triangular flow (v_3) versus centrality for different transverse spherocity selections in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV using AMPT [2].

event-by-event fluctuations should not be affected by selections based on transverse spherocity. As high-S_0 events represent isotropic events, the corresponding value of ε_2 is expected to be lower, as shown in Fig. 1.

Figure 2 shows v_2 and v_3 versus collision centrality and transverse spherocity in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV using AMPT. Both v_2 and v_3 are estimated using the two-particle correlation method, the methodology and corresponding track selection cuts can be found in Ref. [2]. Here, both v_2 and v_3 increase from the most central to the mid-central collisions, where the rate of increase gradually decreases, and the v_3 value starts decreasing again towards the peripheral collisions. This is because, as one moves from most-central to mid-central collisions, the anisotropy increases, and as a result, both v_2 and v_3 increase. However, towards the peripheral collisions, ε_2 and ε_3 cannot transform into v_2 and v_3 due to fewer participants to carry the information [2]. Additionally, both v_2 and v_3 show a significant dependence on event selections based on S_0, low-S_0 events have higher v_2 and smaller v_3 compared to the S_0 integrated case. While v_2 shows a similar S_0 dependence as ε_2, the manifestation of finite transverse spherocity dependence on v_3 when ε_2 is independent of S_0 is a matter of importance. Another crucial point to note is that while v_2 is found to be anti-correlated with S_0 selection, v_3 is observed to be positively correlated. This behaviour between v_2 and v_3 is also observed in experiments with respect to a different event shape classifier, the reduced flow vector [3].

Summary

In summary, we have studied the initial azimuthal anisotropies, such as eccentricity (ε_2) and triangularity (ε_3), and final state azimuthal anisotropies, *viz.,* elliptic flow (v_2) and triangular flow (v_3) as a function of centrality and transverse spherocity. ε_2, v_2 and v_3 show appreciable spherocity dependence, whereas ε_2 do not show any spherocity dependence. Both ε_2 and v_2 show anticorrelation with S_0 while v_3 shows a positive correlation.

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