Quark number, transverse momentum and centrality dependent flow harmonics of (multi-) strange hadrons in Au+Au collisions at $\sqrt{s_{NN}} =$ 200 GeV

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Introduction

The primary goal of the study of heavy-ion collisions is to know about the QGP medium and its properties. Anisotropic flow is a powerful probe to measure the existence of strongly interacting partonic matter formed at high energy densities and temperatures. Anisotropic flow arises from the spatial asymmetry in the initial geometry of the collision transformed into momentum anisotropy combined with the initial state inhomogeneities of the system's energy density. It is calculated in the form of Fourier series expansion coefficients known as the harmonics of flow with respect to the event plane [1].

$$\frac{dN}{d\phi} = 1 + \sum_{n=1}^{\infty} 2v_n \cos[n(\Phi - \Psi_n)]$$

The n^{th} order flow harmonics v_n are represented by the Fourier coefficients as :

$$v_n = < \cos[n(\Phi - \Psi_n)] >$$

where Φ is the azimuthal angle of the produced particles, n is the order of harmonics and Ψ_n is the reaction plane angle. The averaging is performed on overall particles in a single event and overall events.
In this article, we have discussed elliptic flow v_2, triangular flow v_3, and quadrangular flow v_4 of (multi-) strange hadrons produced in Au+Au collisions at 200 GeV within the framework of HYDJET++ model.

Model

The basic features of the HYDJET++ model are described in reference [2]. It consists of two independent components namely, soft and hard processes, and simulates them simultaneously. The soft part represents thermal hadron production from preset freezeout surface by the FASTMC generator. The soft part includes the generation of the 4-momentum of hadrons, fluid flow 4-velocity, and the two- and three-body decays of resonances with branching ratios taken from the SHARE particle decay table. The hard part includes the generation of multi-jets according to binomial distribution in PYQUEN. The PYQUEN generates initial parton spectra by modifying jet which PYTHIA produces and its radiative and collisional energy loss of partons in dense zone. The final hadronization of partons and in medium emitted gluons is performed using the Lund string model. The more details about flow harmonics are available in reference [3].

Results and Discussions

Figure 1 (a) shows v_2 as a function of p_T obtained from HYDJET++ for (multi-) strange baryons using reaction plane method [3] in Au+Au collisions at $\sqrt{s_{NN}} =$ 200 GeV. This method covers a fraction of contribution from event-by-event flow fluctuations and non-flow contribution mainly including resonance decays and jets. The results for $\Lambda + \overline{\Lambda}$ and $\Xi^- + \overline{\Xi}^+$ are presented in (0-10%) and (40-80%) centrality intervals. $\Omega^- + \overline{\Omega}^+$ results are shown for (0-10%) and (30-80%) centrality intervals. The model results of elliptic flow are compared with the experimental results from STAR collaboration [4–7]. The model results for v_2 match well with experimental results at all p_T in central collisions. However, the model overestimates the experimental data for v_2 at high p_T in peripheral collisions. It may be due to the nonflow effects [4, 5]. Also, multi-strange baryons have small hadronic cross-sections and thus could be unaffected by the hadronic rescattering in the later stages of the collision. Similarly, in figures 1(b), and (c), the model results for v_3 and v_4 are shown as a function of p_T in (0-10%), and (40-50%) centrality for hyperons. We observe that v_n increases with increasing centrality. v_2 shows a strong dependence on centrality while v_3 and v_4 show weak dependence on centrality. Figure 2 presents the comparison of model results of NCQ scaling of v_n and available experimental results in (0-10%) centrality interval. The number of constituent quark scaling shows that the collective flow was generated at the partonic level. In the number of constituent quark scaling processes, at a given p_T, hadrons are created from n_q quarks with transverse momentum p_T/n_q.

Conclusion

We have shown higher flow harmonics of multi-strange hadrons in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV which is obtained by the HYDJET++ model. The model gives a better description of the bulk matter properties in heavy ion collisions. Model results match well with experimental results in central collisions compared to the peripheral collisions for strange hadrons. The NCQ scaling of flow harmonics for strange hadrons is

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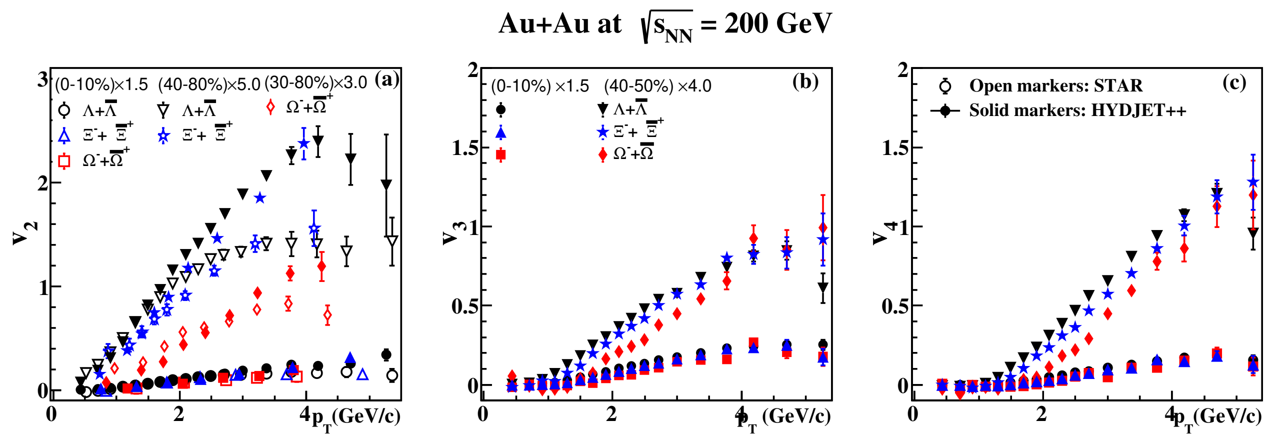

FIG. 1: v_n as a function of p_T of strange hadrons ($\Lambda + \overline{\Lambda}$, $\Xi^- + \overline{\Xi}^+$, and $\Omega^- + \overline{\Omega}^+$) in various centrality intervals. Open markers and solid markers represent experimental results at STAR [4, 5, 7] and HYDJET++ [3].

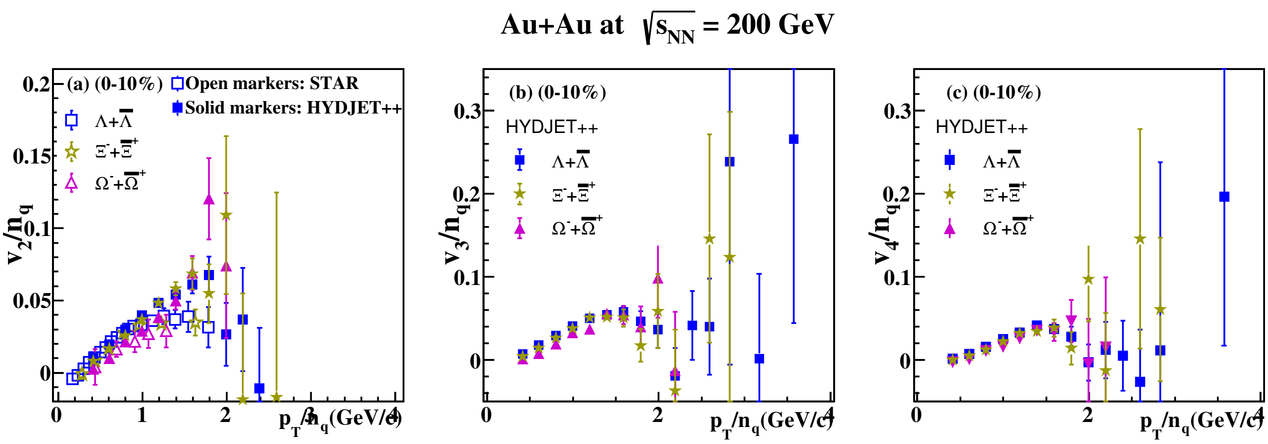

FIG. 2: p_T/n_q dependence v_n/n_q of strange hadrons at (0-10%) centrality interval [7].

approximately equal in each centrality and independent of quark content. The flow of strange hadrons shows the same behaviour as non-strange hadrons. It indicates that similar flow strength exists in u, d, and s quarks [6]. v_2 magnitude is larger at all centralities than higher flow harmonics, except for the most central collisions. This indicates that initial geometry fluctuations dominate in central collisions. v_n magnitude increases when we move from central to peripheral collisions.

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