Effect of rapidity range on the scaling of transverse flow in asymmetric collisions

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Introduction

Anisotropic flow is a distinctive collective behaviour of particle emission and has been proved as a good tool to explore the hot matter produced, as it can furnish the foremost information about equation of state and transport properties of the formed matter in heavy-ion collisions[1]. Directed flow is one of the mechanisms of final momentum anisotropy that have been proposed to researching its dependance on input parameters(incident energy, impact parameter, mass, isospin etc.) and rapidity distribution[2]. The parameter of directed flow is quantified by first order fourier coefficient $v_1 = < \cos\phi > = \sum_{i=1} \frac{p_x^i}{p_t^i}$ from the azimuthal distribution of detected particles at mid-rapidity as[3]:

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

where ϕ is azimuthal angle between the transverse momentum of the nucleons and the reaction plane and p_x and p_y are, respectively, the projection of particle transverse momentum parallel and perpendicular to the reaction plane and $p_t = \sqrt{p_x^2 + p_y^2}$ defined as transverse momentum.
The main motive of this article is to study the scaling achieved in mass asymmetric collisions. However, the symmetry energy, equation of state and isospin dependent and independent cross-section role have been varied to examine the scaling[4] for symmetric. In the present work, we attempt to study the transverse momentum dependence and scaling of the directed flow for different mass fragments for selected rapidity range. Isospin-dependent quantum molecular dynamics (IQMD)model has been used to meet the objective of the study.

Methodology

In IQMD model[5], the isospin degree of freedom enters into the calculations via Symmetry potential, cross-sections and Coulomb interactions. The nucleons of target and projectile interact via two and three-body Skyrme forces, Yukawa potential and Coulomb interactions. In addition to the use of explicit charge states of all baryons and mesons, a symmetry potential between protons and neutrons corresponding to the Bethe-Weizsacker mass formula has been included.
In IQMD model, baryons are represented by wave packet

$$f_i(\vec{r}, \vec{p}, t) = \frac{1}{\pi^2\hbar^2} \cdot e^{-(\vec{r}-\vec{r_i}(t))^2 \frac{1}{2L}} \cdot e^{-(\vec{p}-\vec{p_i}(t))^2 \frac{2L}{\hbar^2}}. \quad (2)$$

The centeroids of these wave packets propagate using classical Hamilton equations of motion:

$$\frac{d\vec{r_i}}{dt} = \frac{\partial\langle H \rangle}{\partial p_i} \; ; \; \frac{d\vec{p_i}}{dt} = -\frac{\partial\langle H \rangle}{\partial r_i} \quad (3)$$

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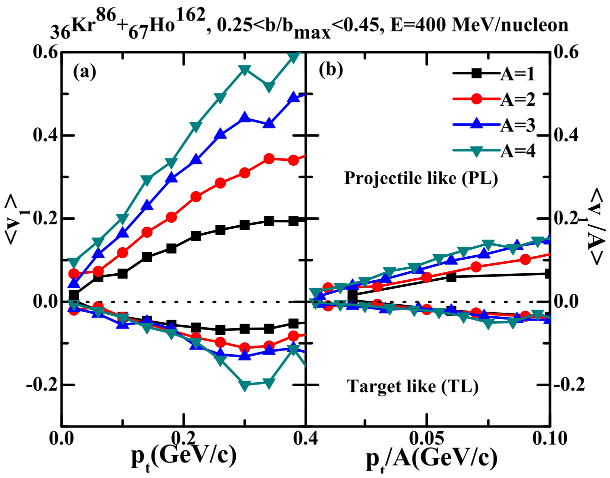

FIG. 1: (a)Left panel shows the transverse momentum(p_t) dependance of directed flow of different mass fragments for ${}^{86}_{36}Kr + {}^{162}_{67}Ho$ collisions at incident energy 400 MeV/nucleon for centrality range $0.25 < b/b_{max} < 0.45$ for $\mid 0.3 < Y_{c.m.}/Y_{beam} < 0.5 \mid$ and (b)Right panel shows the nucleonic scaling of directed flow with transverse momentum for the selected rapidity range.

with

$$\begin{aligned} \langle\, H \,\rangle &= \langle\, T \,\rangle + \langle\, V \,\rangle \\ &= \sum_i \frac{p_i^2}{2m_i} + \sum_i \sum_{j>i} \int f_i(\vec{r},\vec{p},t) V^{ij}(\vec{r}',\vec{r}) \\ &\quad \times f_j(\vec{r}',\vec{p}',t) d\vec{r} d\vec{r}' d\vec{p} d\vec{p}'. \end{aligned} \tag{4}$$

Results and Discussions

We have simulated the reactions of ${}^{86}_{36}Kr + {}^{162}_{67}Ho$ collisions at incident energy 400 MeV/nucleon for centrality range $0.25 < b/b_{max} < 0.45$, where the particles corresponding to $Y_{c.m.}/Y_{beam} > 0.1$ have been defined as projectile-like(PL), whereas $Y_{c.m.}/Y_{beam} <$ -0.1 constitutes the target-like(TL) particles. Left panel of Figure 1 shows the p_t dependence of A=1, 2, 3 and 4 fragments of $< V_1 >$ for the above said rapidity range. The reason for selecting the above said rapidity range, was to explore the correlation between fragments transverse-momentum and their mass. It would be interesting to see whether the nucleon constituting the fragments are having some transverse momentum or not. One can clearly see the rate of mass asymmetry in fig 1(a). Right panel shows that different curves of $< V_1/A >$ for different mass fragments do not fall on the same line, it shows that the scaling among the nucleons cannot be achieved for mass asymmetric reactions. The detailed work in this direction is in progress.

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