A comparative study of excitation function of elliptical flow with experimental findings and system size dependence

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Introduction

The collective flow of particles in heavy-ion collisions enjoy special status due to its sensitive response to model ingredients that define equation of state. This collective motion of particles can be studied by directed and elliptical flow. The directed flow, which measures the collective motion of particles in reaction plane, has been studied extensively at BEVALAC, SIS and AGS energies [1]. On the other hand, the elliptical flow, which measures the motion in transverse direction, is studied recently by the several experimental groups. The FOPI, INDRA and ALADIN collaborations [2] are actively involved in measuring the excitation function of elliptical flow from Fermi to relativistic energies. Interestingly, the change in the elliptical flow for $_{79}Au^{197}$ + $_{79}Au^{197}$ reaction is observed from positive to negative value around 100 MeV/nucleon. In the following contribution, we have also tried to observe the same behavior in the presence of Isospin-dependent Quantum Molecular Dynamics (IQMD) model [3] with hard (H) as well as hard momentum dependent (HMD) equations of state (EOS) by varying the model ingredients such as Gaussian width, Clusterisation distance etc.

The Model

The IQMD model treats different charged states of nucleons, deltas and pion explicity, as inherited from the VUU model[4]. The isospin degree of freedom enters into the calculations vai symmetry potential, cross-section and Coloumb interactions. The nucleons of target and projectile interact via two and three body Skyrme forces, Yukawa potential, Coloumb potential and momentum dependent interactions. In addition to the use of explicit charge states of all baryons and mesons, a symmetry potential between protons and neutrons corresponding to Bethe-Weizsacker mass formula has been included. Thus, the interaction potential is given as:

$$V^{ij}(\vec{r}' - \vec{r}) = V^{ij}_{Skyrme} + V^{ij}_{Yukawa} + V^{ij}_{Coul} + V^{ij}_{mdi} + V^{ij}_{sym} \quad (1)$$

Results and Discussion

For this study, we have simulated the reactions of $_{20}Ca^{40}$ + $_{20}Ca^{40}$, $_{54}Xe^{131}$ + $_{54}Xe^{131}$ and $_{79}Au^{197}$ + $_{79}Au^{197}$ between incident energies 50 to 1000 MeV/nucleon at semi-central geometries. In fig.1, the elliptical flow is displayed with beam energy for free nucleons, light charged particles (LCP,s) and intermediate mass fragments (IMF's) over entire rapidity region. The elliptical flow is found to decrease with increase in incident energy for all type of fragments. It is also observed that flow of heavier fragments is large compared to LCP's/free nucleons at all beam energies indicating heavy fragments which mostly originates from the spectator matter remains with in the reaction plane. On the other hand, the elliptical flow is decreasing with increase in the system size. This is due to the fact that pressure produced by Coloumb interactions increases with system size.

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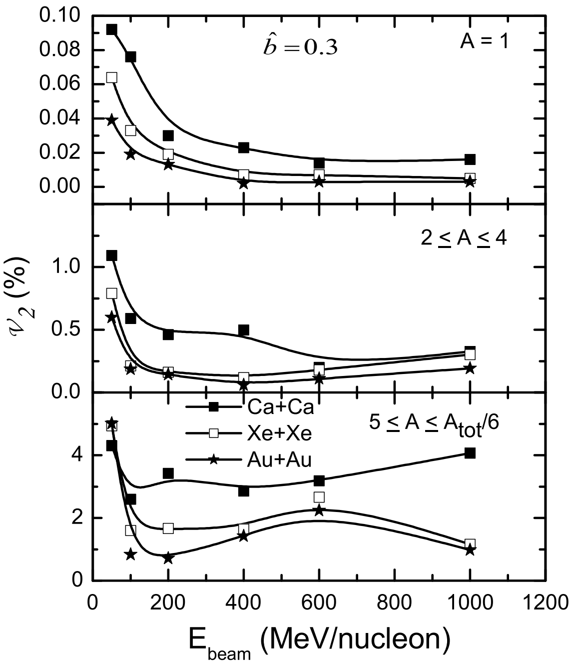

FIG. 1: Variation of elliptical flow with beam energy at $\hat{b} = 0.3$ for different symmetric reactions. The top, middle and bottom panels are for free particles, LCP's amd IMF's, respectively.

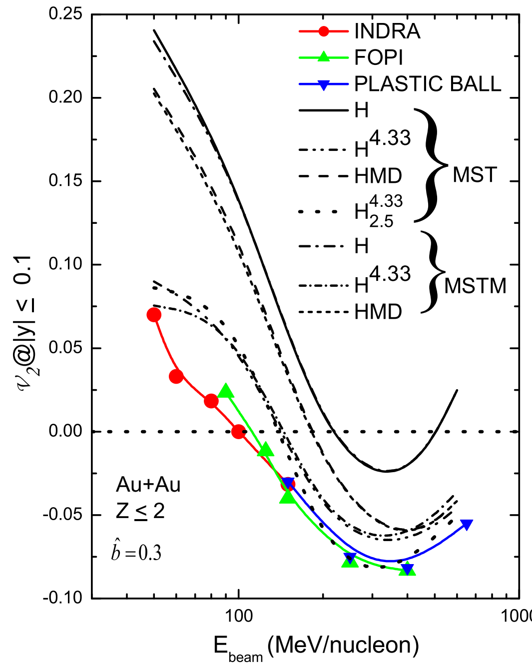

FIG. 2: Variation of elliptical flow with beam energy at $|y| = |\frac{y_{c.m}}{y_{beam}}| \leq 0.1$ for ${}_{79}Au^{197} +_{79} Au^{197}$ reaction. Here comparison is shown with experimental findings of INDRA, FOPI and PLASTIC BALL Collaborations[2].

In fig.2, we show v_2@mid rapidity ($|y| = |\frac{y_{c.m}}{y_{beam}}| \leq 0.1$) for $Z \leq 2$ as a function of incident energy. The theoretical results are compared with experimental findings of INDRA, FOPI and PLASTIC BALL by varying the model ingredients such as Gaussian width, Clusterization distance and equation of state. The agreement with experimental findings is observed at narrow Gaussian width ($L = 4.33$) and $R_{Clus} = 2.5fm$ with hard equation of state.

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