Effect of isospin momentum dependent interactions on elliptical flow

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Introduction

The collective flow (directed and elliptical) has contributed a lot towards the exploration of isospin dependent part of the nuclear equation of state. Previous findings provide evidence about the elliptical flow as a probe for the form and strength of the symmetry energy in heavy-ion collisions at intermediate energies [1]. The elliptical (or squeezed-out) flow, is generated from the mid-rapidity region (core-participant zone) which gives us crucial information regarding the interactions between the nucleons. No doubt, the reaction output is significantly affected by the momentum dependent interactions. The momentum dependent equation of state provides more accurate description of the experimental findings [2].

Considering the fact that nuclear matter interactions are isospin dependent and the reaction output is significantly affected by the isospin content of the system. We here show the effect of isospin momentum dependent interactions on the elliptical flow of fragments. Till now, the momentum dependent interactions are assumed to be isospin independent. To extract the essential isospin physics via. elliptical flow, we here also take the density dependence of symmetry energy into consideration.

The Model

Our calculations are carried out within the framework of isospin dependent quantum molecular dynamics (IQMD) model [3]. It is a semi-classical model which describes the heavy-ion collisions on an event by event basis. In IQMD model, the centroid of each nucleon propagates under the classical equations of motion.

$$\frac{d\vec{r_i}}{dt} = \frac{dH}{d\vec{p_i}} \; ; \; \frac{d\vec{p_i}}{dt} = -\frac{dH}{d\vec{r_i}} \cdot \quad (1)$$

The symmetry energy strength is found to vary with the density of the system as [4]:

$$E(\rho) = E(\rho_o)(\rho/\rho_o)^{\gamma} \quad (2)$$

For the present study, we take $\gamma = 0.66$. To explore the role of isospin in heavy-ion collisions, we introduced the isospin dependence of momentum dependent interactions and analyzed its impact on heavy-ion collisions via. elliptical flow. We here introduced the momentum-dependent interactions as a function of isospin term $V_{Iso-MDI}$ in IQMD model as:

$$V_{Iso-MDI} = (1.0 \; - \; 0.5 \; T_3^i \; T_3^j).V_{mdi} \quad (3)$$

Here, T_3^i and T_3^j are the isospin component of interacting baryons. We name this version as IQMD(Th01) model [5].

Preliminary Results

For the present analysis, we simulated the reactions of $^{197}_{79}Au$ + $^{197}_{79}Au$ and $^{120}_{40}Zr$ + $^{120}_{40}Zr$, at the incident energy of 100 MeV/nucleon for fixed colliding geometry i.e. impact parameter b = 5 fm. It is worth mentioning that both the mean field and nucleon-nucleon collisions will play a significant role

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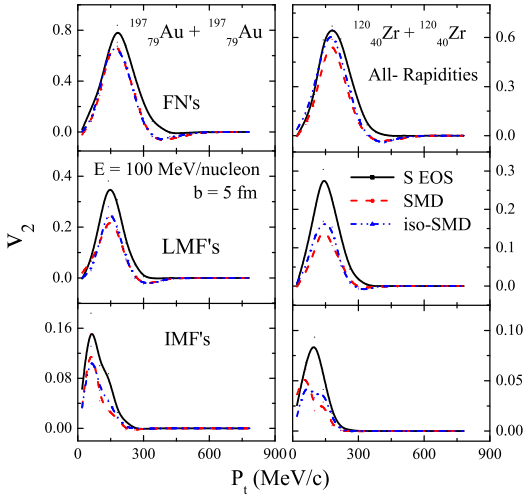

FIG. 1: The transverse momentum dependence of elliptical flow v_2 for the systems $^{197}_{79}Au + ^{197}_{79}Au$ and $^{120}_{40}Zr + ^{120}_{40}Zr$ for FN's [A=1] (top panel), LMF's [$2 \leq A \leq 4$] (middle panel) and IMF's [$5 \leq A \leq A_{tot}/6$] (bottom panel) subjected to various equation of states for entire rapidity region. The incident energy is 100 MeV/nucleon and impact parameter b = 5 fm.

at this incident energy. We display the transverse momentum dependence of elliptical flow v_2, summed over the entire rapidity region, for free nucleons, light and intermediate mass fragments for the soft (S), soft momentum dependent (SMD) and isospin dependent SMD (iso-SMD) equation of state, in Fig. 1. One can clearly observe that free nucleons as well as nucleons bound in fragments (light and intermediate) shows considerable sensitivity towards the various equations of state. In all cases, the inclusion of momentum dependent interactions (isospin independent/isospin dependent) yields lesser positive value of v_2. The repulsion generated due to momentum dependent interactions causes the larger scattering of nucleons, especially in the spectator zone, where the nucleons with larger relative velocities will move apart. In isospin momentum dependent interactions, this repulsion will also depend on the isospin component of the interacting baryons. The isospin momentum dependent equation of state results in the larger peak value of v_2 in the entire rapidity (participant + spectator) region, compared to momentum dependent equation of state.

Although, the momentum dependent equation of state affects the elliptical flow drastically. The isospin momentum dependent interactions have a considerable impact on the elliptical flow associated to light and heavy mass fragments.

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