Role of isospin momentum dependent interactions in multifragmentation.

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Introduction

The heavy-ion collisions (at intermediate energies) are best suited to extract the information regarding the nuclear equation of state as well as its isospin dependence. A full and proper accounting of the isospin is required to understand the complex dynamics involved in the reaction. The multifragmentation is one of the crucial parameters used to explore the role of symmetry energy as well as its density dependence in heavy-ion collisions.

Theoretical investigations provide evidence that the symmetry energy or isospin dependent part of the nuclear equation of state can be extracted from the isotopic distribution of primary fragments [1]. At the same time, the momentum dependence of equation of state has a significant impact on the fragment production, especially at the peripheral collisions [2]. By now, it is evident, that in intermediate energy heavy-ion collisions, the neutron-neutron, neutron-proton and proton-neutron interactions are entirely different. That is why, it is interesting to include the isospin dependence of momentum dependent interactions. In this paper, we demonstrate the influence of isospin momentum dependent interactions on multifragmentation.

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 the production of various light and heavy mass fragments. We here speculated 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 reaction of $^{197}_{79}Au + ^{197}_{79}Au$, at the incident energy of 100 and 600 MeV/nucleon. Both the mean field and nucleon-nucleon collisions govern the reaction dynamics at 100 MeV/nucleon. However, at the incident energy of 600 MeV/nucleon, the mean field will play negligible role and the binary nucleon-nucleon collisions will dominate the dynamics of reaction. For the better understanding of isospin effect, results are spanned over

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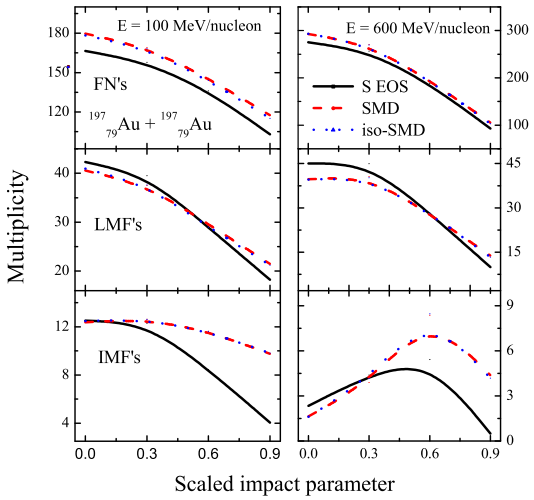

FIG. 1: The impact parameter dependence of multiplicity for the system $^{197}_{79}Au + ^{197}_{79}Au$ for FN's [A=1] (top panel), LMF's [$2 \leq A \leq 4$] (middle panel) and IMF's [$5 \leq A \leq A_{tot}/6$] (bottom panel) subjected to various equation of states.

the whole colliding geometry. We display the multiplicities of free nucleons, light and intermediate mass fragments for the soft (S), soft momentum dependent (SMD) and isospin dependent SMD (iso-SMD) equation of state, for the whole colliding geometry in Fig. 1. Our findings indicate that the intermediate mass fragment multiplicity shows a rise and fall behaviour at the incident energy of 600 MeV/nucleon. Whereas, light mass fragment and free nucleon multiplicity decreases monotonically with an increase in impact parameter of the reaction. This is due to the fact that IMF's are generated solely from the spectator zone, which hardly takes part in the reaction. However, the free nucleons and light charged particles originate from the participant zone (or fireball zone). At 100 MeV/nucleon, the mean field plays a significant role and the IMF production is maximum at central collisions due to the less violent phase of the reaction. The momentum dependence of equation of state affect the multiplicity of fragments over the whole colliding geometry. There seems no direct effect of isospin dependence of momentum dependent interactions on the yield of light and heavy-mass fragments.

The phenomenon of fragmentation takes place at the later stages of reaction, when the nucleons from the participant as well as spectator zone hardly interact with each other. Therefore, it is concluded that the fragment production is insensitive towards the isospin momentum dependent interactions. Whereas, momentum dependent interactions have a considerable impact on multifragmentation.

Acknowledgement : This work has been supported by a grant from the Department of Science and Technology, Government of India [Grant No. SR/S2/HEP-0021/2010].

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