Influence of momentum dependent interactions on intermediate mass fragment production

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Introduction

With the availability of radioactive ion beam (RIB) facilities at GANIL in France, Rikagaku Kenyusho (RIKEN) in Japan, Cooler Storage Ring (CSR) in China and many more upcoming facilities for RIB at Michigan state university [1], one has the possibility to study the properties of isospin asymmetric nuclear matter. The ultimate goal of such studies is to extract information on the nuclear equation of state (NEOS) of isospin asymmetric nuclear matter.

At low incident energies, a large impact of collisions is needed to break the system into pieces of different sizes, which is possible only for central collisions. On the other hand, the excitation energy deposited in the system is very large at higher incident energies. Therefore, central collisions break the matter into much smaller pieces and one rarely sees intermediate mass fragments (IMFs) or heavier mass fragments (HMFs). Moreover, the mutual correlations among nucleons are preserved in peripheral nucleus nucleus collisions; therefore, not much deviation from the initial picture will be seen. The maximum number of IMFs can only be seen at semi-central impact parameters.

It is well known that the outcome of a reaction depends not only on the density, but also on the momentum space [2]. The momentum dependent interactions (MDI) in heavy-ion collisions play an important role in understanding the fragmentation process which includes different kind of fragments. MDI reduces the production of fragments in central collisions whereas it enhances the same in peripheral collisions [3]. In the recent years, Puri and co-workers investigated the role of MDI by using quantum molecular dynamics (QMD) and isospin-QMD (IQMD) model [4]. Interestingly, most of the studies take symmetric or nearly symmetric reactions into account. On the contrary, few attempts exist in the literature that shed light on the consequences of implementing momentum dependent interactions on fragmentation by including the effect of mass asymmetry. Therefore, it is of interest to use both soft and hard momentum dependent interactions (SMD and HMD). An attempt has been made to study the effect of mass asymmetry in the presence of momentum dependent interactions. The isospin dependent quantum molecular dynamics (IQMD) model is used for the present [4].

Results and Discussions:

To address this, we here present a study of different asymmetric reactions of $_{8}O^{17}+_{11}Na^{23}$, $_{7}N^{14}+_{12}Mg^{26}$, $_{5}B^{10}+_{14}Si^{30}$,

$_3Li^6+_{16}S^{34}$ for total mass A= 40 (in each case) at incident energies of 50 MeV/nucleon to 600 MeV/nucleon and at a semi-central impact parameter (b/b_{max} = 0.3) . While total mass of the reactions remain fixed, the mass asymmetry is varied by changing neutrons/protons number. We demonstrate that the momentum dependent interactions have a large impact on the fragment production. The clusterization is done using the minimum spanning tree (MST) method, in which, nucleons are bound if $R_{clus} \leq 4$ fm [5].

In figure 1, we display the energy dependence of intermediate mass fragments (IMFs) [$5 \leq m \leq A_{tot}/3$] for different values of η = 0.1, 0.3, 0.5 and 0.7. The value of A_{tot} is kept fixed as 40 units. The production of IMF's show clear decrease with increase in energy. This might be due to the breaking of spectator part as the momentum dependent interactions (MDI) have repulsive nature. At low energies, number of collisions gets suppressed and most of the matter is in the form of IMF's. But at higher energies, the reaction dynamics changes drastically. This leads to the production of more light mass fragments (LMF's) and heavy mass fragments (HMF's).

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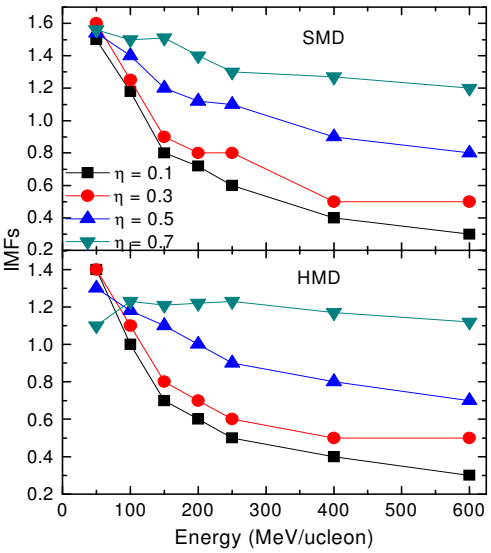

Fig:1 The variation of IMF's with energy using SMD and HMD at semi-central impact parameter.

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