To optimize the spatial and momentum constraints for fragment production

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1. Introduction

Experimentalist studied the multifragmentation using different nuclei and at different incident energies. They investigated in multifragmentation two type of collisions symmetric and asymmetric.

Theoretician on the other side use dynamical models in which two well defined nuclei collide with each other and produce a piece of hot and dense nuclear matter which remains for a very short span of time and this piece of nuclear matter break into light and heavy mass fragment [1]. Firstly one has to generate the phase space of nucleons by using dynamical model and then clusterize these nucleons into fragments by using secondary algorithm in co-ordinate space.

Apart from the coordinate space we also check their relative momenta and put a restriction in momentum space. It would be of interest to optimize the different values of clusterization parameter for a fragment; these depend on the distance between two nucleons. In the present study, we vary the value of R_{clus} between 2-8 fm. We use Minimum Spanning Tree with momentum cut (MSTM) method to check the relative momentum of nucleons. So, along with the restriction on the spatial arrangement of nucleons, a restriction is put on the momentum space of nucleons i.e. $|p_\alpha - p_\beta| \leq P_{clus}$. We vary the value of P_{clus} between 130-300 MeV/c. The present study is carried within the framework of isospin-dependent quantum molecular dynamics(IQMD)model [2]

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2. Results and Discussion

We present the analysis for different system size effects, excitation energies and colliding geometries for different values of R_{clus} and P_{clus} with an isospin-dependent reduced cross-section ($\sigma = 0.9\sigma_{NN}$)[3]. For our study, the reactions of ${}^{40}_{18}Ar + {}^{45}_{21}Sc$ ($\hat{b} = 0.4$, L=0.5L), where L=8.66 fm^2 ${}^{129}_{54}Xe + {}^{139}_{57}La$ ($\hat{b} = 0 - 3fm$, L=0.7L), and ${}^{197}_{79}Au + {}^{197}_{79}Au$ ($\hat{b} = 2.5fm$, L=L) are simulated. The above reactions were simulated between 35 and 200 MeV/nucleon. The reaction dynamics are followed until 200 fm/c and then clusterization is performed with the MST method.

In Fig. 1, we show that when the momentum cut increases from 130-300 MeV/c the number of intermediate mass fragments also increases. We find a strong effect of the cut (in the relative momentum of nucleons) on the fragment multiplicity in the central collisions, whereas the effect is smallest for peripheral collisions. The idea of imposing a cut in momentum space is to avoid the creation of fragments which are not properly bound and will either decay after a while or will emit nucleons in the course of time. For low values of the momentum cut interactions are attractive, therefore no IMFs are produced when the distance between two nucleons is 2 fm, but IMFs are produced for nucleons in which the separation is more than 3 fm. For higher values of the momentum cut (i.e. for P_{clus} is equal to 240 and 300 MeV/c), when we vary the distance between the nucleons from 2 to 4 fm, we observe that same number of IMFs are produced for $R_{clus} = 4$ fm, for these higher value of momentum cut. In Fig. 2, asymmetric reactions of ${}^{129}_{54}Xe + {}^{139}_{57}La$, ${}^{40}_{18}Ar + {}^{45}_{21}Sc$ are displayed as a function of beam energy at scaled impact parameter $\hat{b} = 0.3$ (semicentral collisions)

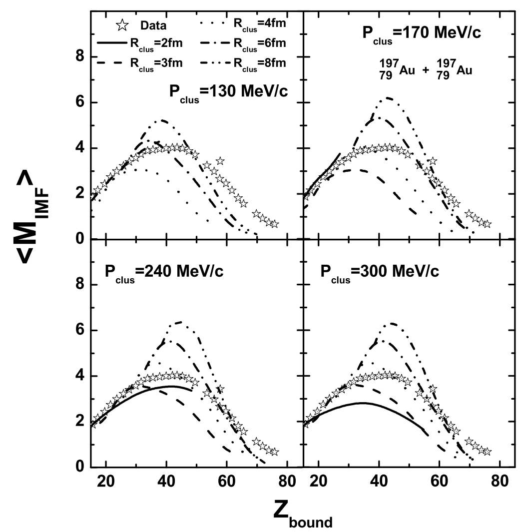

FIG. 1: Mean multiplicity of IMFs as a function of Z_{bound} for Au+Au system.

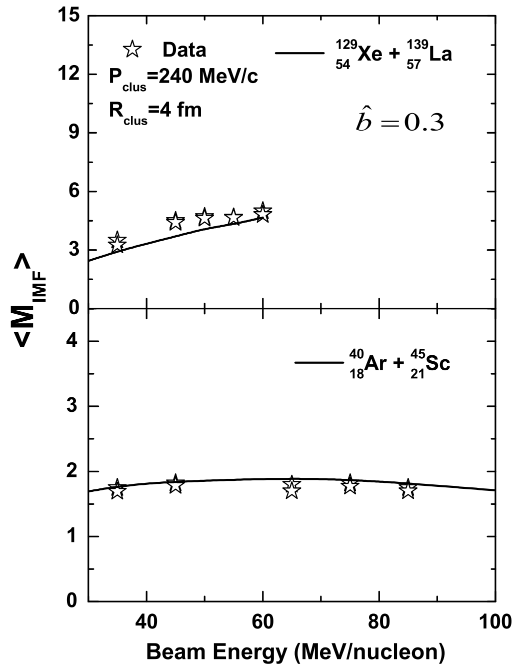

FIG. 2: The average multiplicity of IMFs as a function of beam energy for different reactions. The star symbol represent the NSCL ecperimental results

using ($\sigma = 0.9\sigma_{NN}$) for $P_{clus} = 240$ MeV/c and $R_{clus} = 4$ fm. Final state results are also compared with the NSCL experimental data. We see that our results are in good agreement with the experimental data. For heavier systems like Xe+La, multiplicity of IMFs increases with an increase in beam energy but for Ar+Sc, $\langle M_{IMF} \rangle$ decreases with increased beam energy. From the result obtained we predict that the effect on fragment production is stronger if relative momentum between two nucleons is 240 MeV/c at a spatial separation of 4 fm. We compare our results with ALADIN and NSCL [4] for ${}^{197}_{79}Au +{}^{197}_{79} Au$, ${}^{129}_{54}Xe +{}^{139}_{57} La$, ${}^{40}_{18}Ar +{}^{45}_{21} Sc$.

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