Effect of position and momentum constraints on charge distribution in heavy-ion collisions

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1. Introduction

The rich phenomenology of multifragmentation has been widely explored after two decades of its discovery [1]. It has been experimentally shown that in one single heavy ion collision many intermediate mass fragments (IMFs) are produced, where IMFs are defined as fragments with $5 \leq A \leq A_{tot}/6$. In the earlier literature, the multifragmentation was studied by Jakobsson et al. [2] who measured the charge particle distribution along with their kinetic energy spectra in $^{16}O/^{36}Ar$ induced reaction between 25 and 200 MeV/nucleon representing the various phenomena in heavy ion collisions. These experiments make a stringent test for any theoretical model designed for multifragmentation. The multifragmentation of highly excited heavy nuclei Au+Au was studied by INDRA collaboration at GSI in the beam energy range between 60 MeV/nucleon and 150 MeV/nucleon. The goal of these experiments was to extend the investigation of fragmentation processes, of the associated collective flow, of their link to the liquid-gas phase transition, and generally of the production and decay modes of heavy nuclei near their limit of stability to bombarding energies. In the present paper, we want to see the effect of position (R_{clus}=4 fm) and momentum constraints (P_{clus}=240 MeV/c) on charge distribution for different systems. The present study is carried out within the framework of isospin-dependent quantum molecular dynamics(IQMD)model [3].

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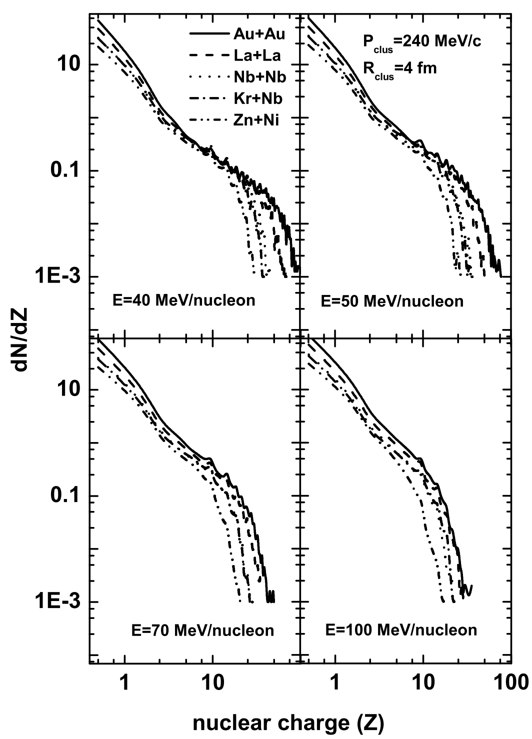

FIG. 1: The atomic charge distribution dN/dZ as function of charge for various systems at different energies for R_{clus}=4 fm and P_{clus}=240 MeV/c.

2. Results and Discussion

We here simulate reactions of $^{86}_{36}Kr$ + $^{93}_{41}Nb$ (b=4 fm, L=0.6L), $^{93}_{41}Nb$ + $^{93}_{41}Nb$ (b=3 fm, L=0.7L) $^{64}_{30}Zn$ + $^{58}_{28}Ni$ (b=2 fm, L=0.6L), $^{139}_{57}La$ + $^{139}_{57}La$(b=3.5 fm, L=0.8L), $^{197}_{79}Au$ + $^{197}_{79}Au$(b=2.5 fm, L=L)where L=8.66

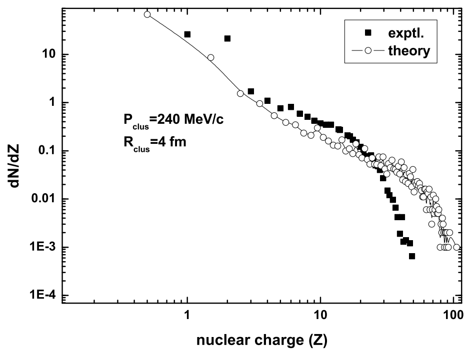

FIG. 2: Spectrum of fragment charge Z for central collisions of $^{197}_{79}Au$ + $^{197}_{79}Au$ at E=40 MeV/nucleon.

fm^2, using a soft equation of state along with R_{clus}=4fm and P_{clus}=240 MeV/c and $\sigma = 0.9\sigma_{NN}$ at incident energies between 40 and 100 MeV/nucleon [4]. The reactions are followed till the transverse flow saturates. We noticed that predicted value of position and momentum coordinates are agree well with the experimental data of INDRA [5].

In the fig. 1, we display the atomic charge distribution (dN/dZ) as a function of charge (Z) for reactions mentioned above at incident energies of 40, 50, 70 and 100 MeV/nucleon. At low beam energies, the nuclear charge obtained for different system is much larger as compared to that obtained for higher energies. With increasing beam energy the multiplicity of IMFs in central collisions decreases. At these energies only small nuclei, mainly up to mass A = 4, survive. But the atomic charge distribution decreases at low energies and reverse for higher energies. Atomic charge distribution increases with increase in system mass due to the increase in the number of nucleon. With the increase in the incident energy, the slope of the charge distribution becomes steeper, indicating a gradual transition from spectator matter to the disassembly of the system. In the fig. 2, we display the atomic charge distribution (dN/dZ) as a function of charge for $^{197}_{79}Au +^{197}_{79} Au$ at incident energy of 40 MeV/nucleon for R_{clus}=4 fm and P_{clus}=240 MeV/c. In this figure experimental data is taken from INDRA collaboration and is shown by solid square. The theoretical results are repesented by open circles are in good agreement with the experimental results. In other words, the present IQMD model with a soft equation of state along with predicted value of position and momentum coordinates R_{clus}=4 fm, P_{clus}=240 MeV/cand $\sigma = 0.9\sigma_{NN}$ can explain the data much better than any other theoretical calculations. Further study in this direction is in progress.

3. Acknowledgments

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