Effect of incident energy and mass asymmetry on the production of charge fragments

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Introduction

Detection of isolated charge fragments (Z = 1, 2, 3) is a useful tool to understand the nuclear equation of state. Many experimental groups such as INDRA [1] and NIMROD [2] are studying the production of the light charge particles (LCP) near the fermi energy. The effect of mass asymmetry and incident energy on the production of primary LCP's (n, p, d, t, ^3He and α) are studied by NIMROD [2] collaboration. S. Hudan *et al.,* [1] studied the mean multiplicity of evaporated particles and total multiplicity per event for Xe + Sn for central collision at different incident energies.

In this paper, we aimed to study the effect of incident energy on the production of charged fragments (Z = 1, 2, 3). In addition to this, we study the effect of mass asymmetry on the production of charged fragments. This work has been carried out within the frame work of isospin dependent quantum molecular dynamics (IQMD) [3] model.

IQMD Model

IQMD is a semi classical model and an improved version of QMD model. The hadrons propagate using classical Hamiltonian equations of motion, which help to calculate space and momentum co-ordinate of each nucleon after each collision.

$$\frac{d\vec{r_i}}{dt} = \frac{d\langle H \rangle}{d\vec{p_i}} \; ; \; \frac{d\vec{p_i}}{dt} = -\frac{d\langle H \rangle}{d\vec{r_i}}, \quad (1)$$

with

$$\langle H \rangle = \sum_i \frac{p_i^2}{2m_i} + V^{tot} \quad (2)$$

where

$$V^{tot} = V_{Skyrme}+V_{Yukawa}+V_{Coul}+V_{mdi}+V_{sym}$$

$V_{Skyrme}, V_{Yukawa}, V_{Coul}, V_{mdi}, V_{sym}$, respectively, the local (two and three-body) Skyrme, Yukawa, Coulomb, momentum dependent and symmetric potentials. Two nucleons share the same fragment if their centroids are closer than some spatial distance d_{min}:

$$|r_i - r_j| \le d_{min} \quad (3)$$

This is called minimum spanning tree method (MST) [4]. where d_{min} = 4 fm. We use MSTP algorithms for clusterization. MSTP is an improved algorithm over the MST. Here, MSTP allow two nucleons to be part of a fragment if $|p_i - p_j| \le 150 MeV/c$.

Results and discussion

For present study, we simulated the reactions of $^{40}_{18}Ar$ + $^{124}_{50}Sn$ (η = 0.5), $^{32}_{16}S$ + $^{124}_{50}Sn$ (η = 0.6), $^{20}_{10}Ne$ + $^{124}_{50}Sn$ (η = 0.7), $^{10}_{6}C$ + $^{124}_{50}Sn$ (η = 0.8) at incident energies 20, 40, 60 and 80 MeV/nucleon and reaction time is 200 fm/c. We used soft equation of state at scaled impact parameter $\hat{b}$ = 0.3 along with free energy dependent nucleon-nucleon cross-section. Where $\hat{b} = b/b_{max}$ and $b_{max} = 1.12(A_T + A_P)^{\frac{1}{3}}$, A_T and A_P are the masses of the target and projectile respectively.

In Fig.1, one can see a significant effect of incident energy on the production of charged fragments. We display free charge particles (Z = 1) in top panel, fragments with Z =

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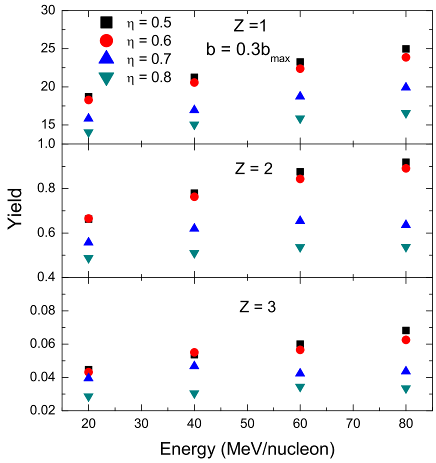

FIG. 1: Average yield of fragments having Z = 1, 2, 3 as a function of energy for different mass asymmetry.

2 and 3 in middle and bottom panel respectively. Due to increase in participant zone, the yield of charged fragments increase with decrease in mass asymmetry. The production of charged fragments increase with increase in incident energy in all three panels. The production of fragments decrease from top to bottom because the instability of fragments increase with increase in the number of protons in the fragment. This is happened due to increase in nucleon-nucleon repulsion between the charge particles (protons).

Acknowledgments

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