Charge contents of fragment produced in heavy ion collision near Fermi energy regime

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Introduction

The heavy ion collisions at intermediate energy is a useful approach in nuclear physics to study the bulk properties of nuclear matter, nuclear equation of state and their reaction dynamics. Near the Fermi energy the multifragmentation enable us to understand the properties of nuclear matter under extreme conditions of temperature and density. Now a days Fermi energy is of central interest because at Fermi energy region both nucleon-nucleon two body collisions and the mean field effects can be studied carefully. Generally fragments multiplicity is influenced by incident energy, impact parameter, cross-section as well as charge and mass asymmetry. Experimentally charged particles (protons) can be easily detected through detectors. In this paper, we have studied the charge particle contents of fragments produced as a function of mass asymmetry. The mass asymmetry of the reaction can be defined by the parameter $\eta = |(A_T - A_P)/(A_T + A_P)|$, where A_T and A_P are the masses of target and projectile respectively. This work has been carried out within the frame work of isospin dependent quantum molecular dynamics (IQMD) model.

IQMD Model

IQMD model [1] is a semi classical model and an improved version of QMD model [2]. The hadrons propagate using classical Hamiltonian equations of motion, which help to calculate space and momentum co-ordinate of each nucleon after each collision.

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

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}:

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

This is called minimum spanning tree method (MST) [3]. where d_{min} = 4 fm.

Results and discussion

The effect of mass asymmetry can be analyzed by using the asymmetric colliding nuclei. For present study, we simulated the reactions $^{40}_{18}Ar + ^{124}_{50}Sn$ ($\eta = 0.5$), $^{32}_{16}S + ^{124}_{50}Sn$ ($\eta = 0.6$), $^{20}_{10}Ne + ^{124}_{50}Sn$ ($\eta = 0.7$), $^{10}_{6}C + ^{124}_{50}Sn$ ($\eta = 0.8$) at fixed center-of-mass energy of 40 MeV/nucleon using MSTP [4] algorithms for clusterization. MSTP is an improved algorithm over the MST. MSTP allowed the maximum relative momentum between the two nucleons to be part of a fragment. Here for all calculations, we used 150 MeV/c relative momentum cut. We used soft equation of state at scaled impact parameter $\hat{b} = 0.3$ along with

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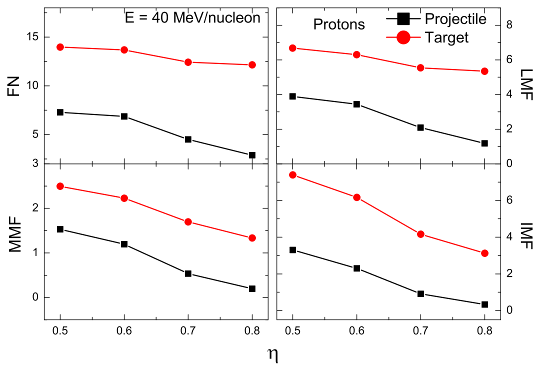

FIG. 1: Average yield of protons for projectile and target as a function of mass asymmetry for FN, LMF, MMF, IMF at E = 40 MeV/nucleon and impact parameter at $\hat{b} = 0.3$.

free energy dependent nucleon-nucleon cross-section for these calculations. In Fig.1, we compare the protonic contribution of free nucleons (FN's) (A = 1), light mass fragments (LMF's) ($2 \leq$ A ≤ 4), medium mass fragments (MMF's) ($5 \leq$ A ≤ 9) and intermediate mass fragments (IMF's) ($5 \leq$ A $\leq A_{tot}/6$) for target and projectile as a function of mass asymmetry. One can clearly see the significant effect of mass asymmetry on fragment production. As expected the protonic contribution in fragment multiplicity decrease with increase in η. This is due to the reduction in participant zone. The average yield of protons is high for target as compare to the projectile. The difference between the protons, contributed by target and projectile increase with increase in mass asymmetry for FN's and LMF's while the inverse scenario is observed in IMF's. This happens because as we increase the mass asymmetry by changing the projectile then the collision zone (participant zone) is decreases with increase in η.

Acknowledgments

This work has been supported by a grant from the Department of Atomic Energy (DAE), Government of India [Grant No. 2012/34/6/BRNS].

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