Multifragmentation and charge distribution of Ar^{40}+Sc^{45} for central collisions

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Introduction

Heavy ion collisions (HIC's) at intermediate and high energies provide a new way to investigate the properties of nuclear matter at high temperature and high density which is connected with the nuclear equation of state (EOS), multifragmentation and liquid gas phase transition [1]. The nuclear multifragmentation, i.e., the production of several intermediate mass fragments (IMF's), particularly attracts a lot of interest since it constitutes a major decay channel of nuclear matter formed in HIC. The dependence of multifragments emission on entrance channel parameters such as incident energy and system size has brought much insight about the characteristics and origin of multifragments emission [2].

Many experimental results of HIC at intermediate and high energies were reported in the past decades. Meanwhile, more theoretical models have been suggested to explain the experimental results. Among various theoretical models developed to study multifragmentation, none can group them into statistical and dynamical ones. The dynamical models (which take the dynamics of the reaction into account) are capable of investigating the evolution of the fragmentation and nucleon-nucleon correlations. Although, both the models are able to explain one or the other feature of experimental findings, we use dynamical model for the present study. Here we use Quantum Molecular Dynamics (QMD) Model [3] .

The Model

The present study is carried out within the framework of quantum molecular dynamics (QMD) model. The QMD model is a time dependent many body theoretical approach based on molecular dynamics treating nuclear correlations explicitly. It is based on an event by event analysis. Here each event is simulated independent of other events. QMD Model has three fold dynamics. First one has to generate the target/projectile. This procedure is called as initialization. The nucleons of projectile/target, then, propagate under the influence of surrounding mean field. This step is termed as propagation. The nucleons are bound to scatter (elastically or in-elastically) if they come too close to each other. This part is dubbed as nucleon-nucleon collisions. Each nucleon is represented by a Gaussian wave packet having time dependent parameters in space and momentum. In this model, nucleons are propagated using classical equations of motion;

$$\dot{r}_i = \frac{\partial H}{\partial p_i}; \dot{p}_i = -\frac{\partial H}{\partial r_i} \qquad (1)$$

where, H is the Hamiltonian and is given by

$$H = \sum_i^A \frac{p_i^2}{2m_i} + \sum_i^A (V_i^{Skyrme} + V_i^{Yuk} + V_i^{Coul}) \qquad (2)$$

where V_i^{Skyrme}, V_i^{Yuk} and V_i^{Coul} are respectively, the Skyrme, Yukawa and Coulomb potentials.

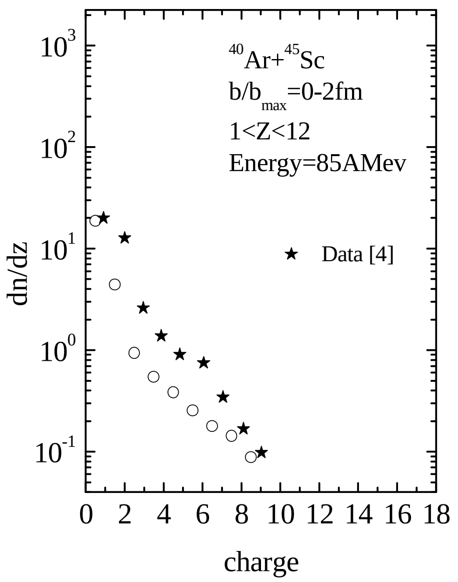

Fig. 1 The charge distribution for the collisions of Ar+Sc having impact parameter 0-2 fm at incident energy of 85AMev.

Results and discussion

We simulate the reactions of Ar^{40} + Sc^{45} at central collisions (b=0-2 fm) at incident energies of 85Mev/nucleon and 115Mev/nucleon respectively. In fig. 1 and fig. 2, we display the charge distribution (open circles) for Ar^{40}+Sc^{45} at 85 and 115AMeV respectively. Also, the condition of 1<Z<12 has to be satisfied in both cases. From figure, we observe the steepening of charge yield (dn/dz) as the beam energy is increased from lower values to higher values, i.e., there is more steepening as we move from 85Mev/nucleon to 115Mev/nucleon. With increasing energy, this slope steepening of charge distribution indicates gradual transition from spectator matter to the disassembly of the system. From figures, we also see that our theoretical calculations matches well with the experimental data at both the energies. These experimental values are taken with MSU FOPI array at the National Superconducting Cyclotron Laboratory (NSCL) using beams from the K1200 cyclotron [4].

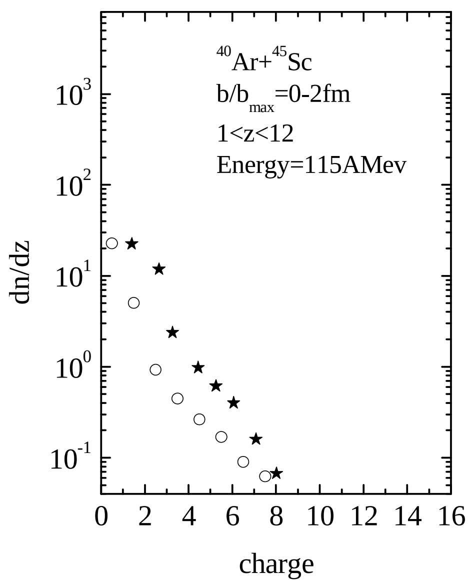

Fig. 2 Same as fig. 1, but at incident energy of 115Mev/nucleon.

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