Study of collision dynamics in heavy-ion reactions

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Introduction

Nuclear physics at low and intermediate energies is one of the most extensively studied branches of physics. Intermediate energy heavy–ion collisions are important for the understanding of hot and dense nuclear matter. The simulation of heavy-ion collisions at intermediate energies has always played a pivotal role in understanding the reaction mechanism [1], nature of nucleon-nucleon (n-n) interactions as well as thermalization achieved by the nuclear system. Similar efforts are also made at lower trail of the incident energy where fusion and cluster-decay processes are important.

Due to formation of compressed and hot piece of nuclear matter at intermediate and relativistic energies, it gives us unique possibility to study the properties of nuclear matter under the extreme conditions of temperature and density. During the collision process, different kinds of interactions are at work which are important in their own. One is also interested to know behaviour of nucleons in the presence of other nucleons in the surroundings.

In present study, we aim to analyze the stopping pattern in the semi-central collisions of Ca^{40}+Ca^{40} at incident energy of 400AMeV, respectively. For the simulation of heavy-ion reactions, we utilize the *quantum molecular dynamics* (QMD) model [2].

Model

The present study is carried out within the framework of quantum molecular dynamics (QMD) model . In this model, nucleon 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

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

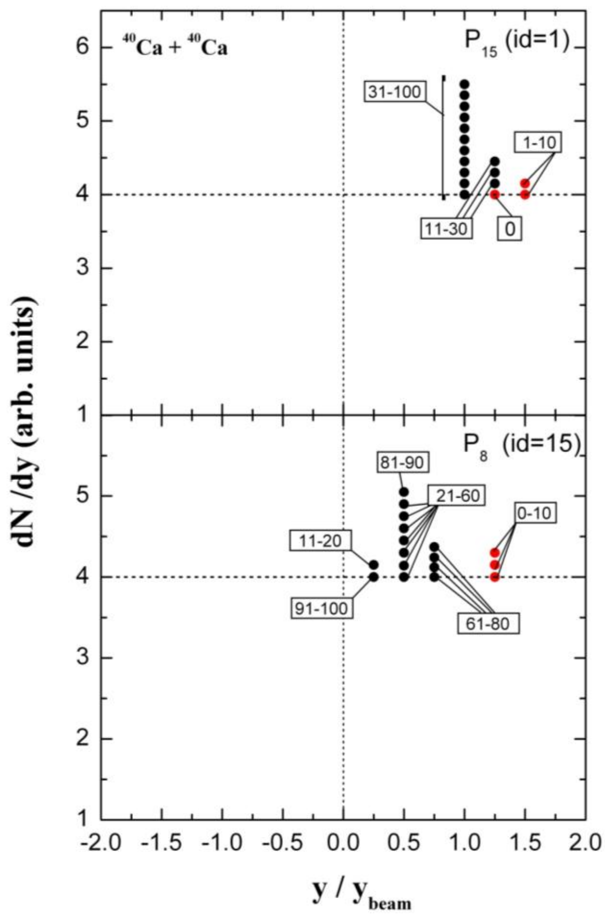

Fig.1: The rapidity distribution dN/dy vs normalized rapidity y/y_{beam} in the Ca (400 AMeV) + Ca collision with b/b_{max} = 0.3. We have shown here the evolution of single spectator nucleon (top) and participant nucleon(bottom).

Results and discussion

Here we studied the stopping pattern of the nucleons facing maximal and minimal number of collisions by analyzing the variation in the rapaidities at different time steps. Fig. 1 shows the variation of the normalized rapidity y/y_{beam} of single spectator nucleon P_{15} (facing zero collision) and participant nucleon P_8 (facing 14 collisions) followed for the time span of 100 fm/c. The probabilities obtained at different intervals but corresponding to same rapidity bin have been displaced along vertical direction. These displaced points have same probability of occurrence. This is done to make the variation in the longitudinal rapidity with time more vivid. At the start of the reaction, both particles are seen at projectile beam rapidity y_{beam}. With advent of the collision process, participant nucleons (suffering 14 collisions) are stopped around *mid-rapidity* with y/y_{beam} =0.25. On other side, the spectator nucleons (as shown in upper panel) still stay in the higher rapidity regime with y/y_{beam} =1. Again, one can also notice that the participant nucleon suffers more fluctuations in its longitudinal rapidity. The spectator particle, however, remains in the projectile's rapidity regime for most of the time [3].

References:

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