Study of system size effects on the energy of peak mass production for light charged particles

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Introduction

The heavy ion collisions at intermediate energies offer an unique opportunity to study the properties of nuclear matter at the extreme conditions of densities and temperatures. Such studies shed light on the equation of state of nuclear matter which is important in the context of nuclear physics as well as astrophysics. Various phenomena such as collective flow and its disappearance, multifragmentation, nuclear stopping and particle production take place at intermediate energies [1, 2]. Out of these, multifragmentation enjoys a special status as it gives insight about the liquid gas phase transition in nuclear matter. All the above mentioned phenomena are found to be dependent on various entrance channel parameters such as incident energy [2], system size [3], colliding geometry [4], mass asymmetry [5] and isospin of the colliding nuclei [6]. During multifragmentation, various intermediate mass fragments (IMFs), light charged particles (LCPs), heavy mass fragments (HMFs), medium mass fragments (MMFs) and free nucleons are emitted. On the theoretical front, various studies have been done to study the energy dependence of fragmentation. These studies have revealed rise and fall behavior of the fragment's multiplicity with incident energy of the colliding pair [7]. The rise and fall behavior can be explained in terms of compressional energy. At low excitation energies, very few IMFs are emitted. This may be because the system does not have sufficient energy to break the colliding pair into a large number of IMFs. With the increase in the incident energy, more energy is available that breaks colliding nuclei into a large number of IMFs. Further increase in the beam energy leads to complete breakup of IMFs into LCPs and free nucleons. In addition to IMFs, one has copious production of LCPs during heavy ion collisions. A recent study has revealed that LCPs can act as a good probe of the symmetry energy [8] and nuclear dissipation. Therefore, the LCPs have significant role in understanding the dynamics of heavy ion reactions. So in present paper, we aim to study the energy dependence of light charged particles multiplicities.

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The Model

The present study is carried out using Isospin-dependent quantum molecular dynamics (IQMD) model [9]. The IQMD model treats different charge states of nucleons, pions and deltas explicitly. The isospin degree of freedom enters into the calculations via symmetry potential, cross sections and Coulomb potential. The nucleons of target and projectile interact by two- and three- body Skyrme forces, Yukawa potential and Coulomb interactions. It consists of three steps of initialization, propagation and scattering. This model has been proved to be quite successful in explaining the experimental results of flow, fragmentation, particle production and nuclear stopping ranging from low to high energies.

Results and Discussion

In fig. 1, we display the multiplicity of light charged particles labelled as ($< N_{LCP} >$) as a function of incident energy in center-of-mass frame. For the present study, we simulated the reactions of ^{40}Ca + ^{40}Ca (A=80),^{58}Ni + ^{58}Ni (A=116), ^{93}Nb + ^{93}Nb (A=186) and ^{197}Au

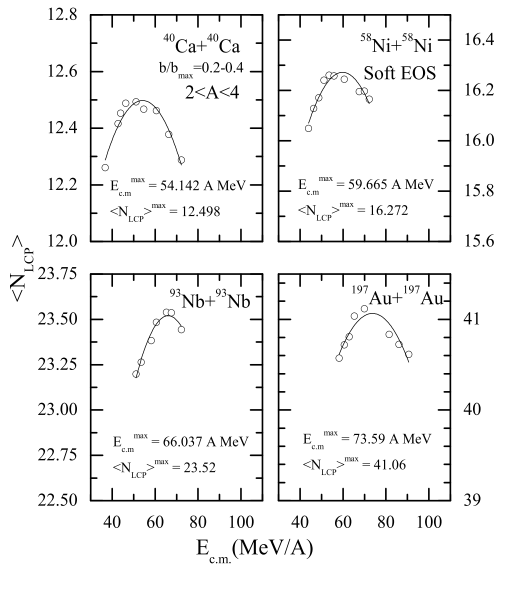

FIG. 1: The center-of-mass frame energy dependence of multiplicity of light charged particles $< N_{LCP} >^{max}$ for various stable systems at semi-central collisions (preliminary results).

+ ^{197}Au (A=394) using soft equation of state at semi-central colliding geometry. From the figure, we see that LCPs multiplicity first increases with energy, reaches a maxima at a particular value of incident energy (labelled as $E^{max}_{c.m.}$) and then decreases with further increase in the incident energy. Therefore, LCPs production also follows a rise and fall behavior as is observed for the IMFs multiplicity. This is because of the fact that initially LCPs production will increase with energy due to greater excitation of the system and further increase in energy would cause the breakup of LCPs into the free nucleons. We also notice that energy as well as multiplicity corresponding to peak mass distribution increases with system mass. This is because of the increasing number of participants in case of heavier systems. Further calculations are in progress to see the exact dependence of $E^{max}_{c.m.}$ and $< N_{LCP} >^{max}$ with system mass and with isospin degree of freedom.

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