Effect of Gaussian width on stability of nuclei in IQMD model.

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1. Introduction

The multifragmentation has been thought to be one of the important phenomenon for the understanding of phase transition in nuclear reactions. One is interested to understand whether the fragments are produced due to coalessence or emerge from the particular region of phase-space. The choice of Gaussian width(interaction range)has also a major role to play in the dynamics of heavy-ion collision.[1, 2]. The typical time for a heavy-ion reaction is around 200 fm/c. For this duration nuclei have to be stable. The stability, and hence the successful simulation of heavy-ion collisions, depend on the solution of two critical problems: how the initial configuration is to be made and how one has to evolve the $A_T + A_P$ system in time. First we determine the position of nuclei in a sphere of radius r=$1.12A^{1/3}$. We generate the phase space but reject those nucleon which would position the centres of two nuclei less than 1.5fm. Successfully initialized nuclei are boosted towards each other with proper centre of mass velocity using relativistic kinematics. Whenever a collision occur, we check the phase space around the final state of scattering partners. For simplicity we assume that each nucleon occupies a sphere in co-ordinate and momentum space. To analyse the result we want to optimize the scaled Gaussian width(SGW)for different colliding nuclei. Scaled gaussian width can be defined as the ratio of Gaussian width used for any nuclei to the Gaussian width used for Au nuclei(i.e. 8.66 fm^2). So that correct mass dependence of Gaussian width can be formulated. The present study is carried within the framework of isospin-dependent quantum molecular dynamics(IQMD)model [1, 3]

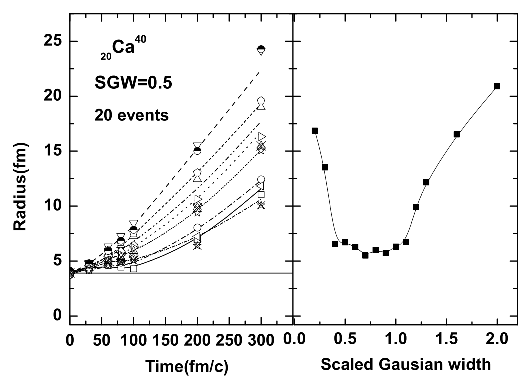

FIG. 1: Root mean square radii of Ca as a function of time(Left panel). Right panel shows radius as a function of scaled Gaussian width.

2. Results and Discussion

If a system is in the ground state, the phase space is densely filled up to a maximum value in co-ordinate and momentum space. It is this property of the ground state which we employ to initialize the nuclei. In this paper we want to check the stability of nuclei by initializing nuclei at ground state energy for different SGW(scaled gaussian width). We study its ground state properties like time evolution of radius, binding energy and largest fragment. After initialization nuclei are boosted towards each other with the proper centre of mass velocity using relativistic kinematics. Furthermore we assume that all particles coming closer than $r = \sqrt{\sigma/\pi}$ suffer collision, whereas those passing at larger distance do not suf-

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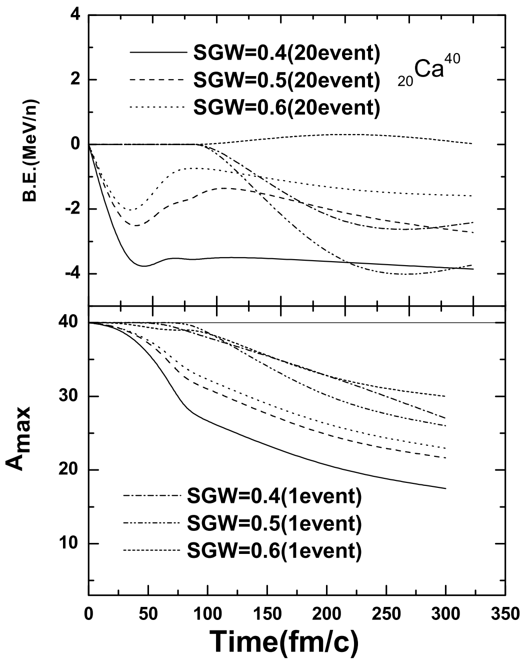

FIG. 2: The Time evolution of A^{max} and binding energy for the Ca nuclei and for different scaled Gaussian width. The calculation are done for soft equation of state.

fer any collision. High energy collision($E_{lab} \geq 500MeV/nucleon$) requires less than 80fm/c as far as single nuclei properties are concerned. However it turns out that in order to investigate the fragmentation process in heavy-ion collision we have to follow the reaction for a considerably longer time. In the Fig.1, we display the time evolution of the root mean square radius of Ca. In this figure radii for 20 differently initialized nuclei has been displayed. It has been found that light nuclei are a little less stable compared to heavy nuclei. These nuclei emit nucleons in time span of 200 fm/c.[4]. Right panel shows radius as a function of scaled Gaussian width(SGW). We obtain a parabola shape as SGW increases. It shows minima at 0.7(SGW) which is suppose to be most stable. In the Fig.2, we display the time evolution of average binding energy per nucleon for 20 events and also for 1 event by enhancing and reducing the Gaussian width 10% from normal SGW of Ca nuclei[1]. The simulation are done for Ca nuclei at ground state energy. More negative the binding energy more stable is the nuclei. If we carry out 20 simulation then 0.6 is SGW which is most stable. For 1 event 0.4 is the SGW which is most stable. In the lower figure we display the time evolution of largest fragment and we see same trend is observed as we note for binding energy. The line closer to largest fragment mass is most stable. Further study in this direction is in progress.

References

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