On the stability of final stage fragments obtained through transport models

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Introduction

The properties of nuclear matter at extreme conditions of density and temperature have been under study for the last few decades. It is now evident that nuclear multi fragmentation is one of the major areas studied in heavy ion collisions [1]. Theoretically, multifragmentation can be studied using various transport models also called primary models along with clusterization techniques that are termed as secondary models. The present work has been carried out within the framework of Isospin Dependent Quantum Molecular Dynamics Model [2] and Quantum Molecular Dynamics Model [3]. We are familiar with the fact that due to the preservation of the correlations and fluctuations among the nucleons, the molecular dynamical models are extensively used to study the formation of the fragments and their stability in heavy ion reactions. One however needs secondary algorithms to identify the fragments. Earlier attempts consist of identification of the fragments on the basis of their spatial correlations named as Minimum Spanning Tree (MST) algorithm [4]. An improvement over MST is MSTP which puts restriction on the coordinate as well as momentum space of the nucleons as discussed by Kumar *et al.* [5]. The stability of the fragments can be studied with the help of persistence coefficient which is related to the change in the nucleon content of fragments between two successive time steps. In the present manuscript, we have concentrated on the stability of the fragments obtained from IQMD and QMD model with the help of different clusterization algorithms (MST and MSTP).

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Results and discussion

For the present study, we have simulated the reaction $^{175}_{79}Au +^{175}_{79} Au,^{197}_{79} Au +^{197}_{79} Au,^{204}_{79} Au +^{204}_{79} Au$ at an incident energy of 400 MeV/nucleon and at a fixed colliding geometry i.e. impact parameter b=3 fm. Here, we have used hard equation of state along with default cross sections available in the two models. The phase space is clusterized using Minimum Spanning Tree (MST) method and Minimum Spanning Tree with Momentum Cut (MSTP) for both IQMD and QMD models. In order to study the stability of fragments, we use Persistence Coefficient defined in Ref. [6]. The persistence coefficient measures the stability of a fragment between subsequent time steps. If a fragment does not emit any nucleon between two successive time steps, the persistence coefficient is one. On the other hand, if the fragment disintegrates completely, the persistence coefficient will be zero. Here, a comparative study on the stability of the fragments produced through both the transport models has been carried out.

Besides, the Fermi momentum of nucleons has been reduced by 44 % in IQMD model to make it equivalent to that of QMD model ($p_f = 150MeV/c$). This has been done keeping in view of the improper binding energy (4-5 MeV/nucleon) for heavy nuclei instead of 8 MeV/nucleon incase of IQMD model. Due to reduced binding energy, the nuclei are prone to bogus evaporation of nucleons [2]. An increase in the Fermi momentum lowers the binding energy, therefore in order to get the desired reaction dynamics, we demand the following

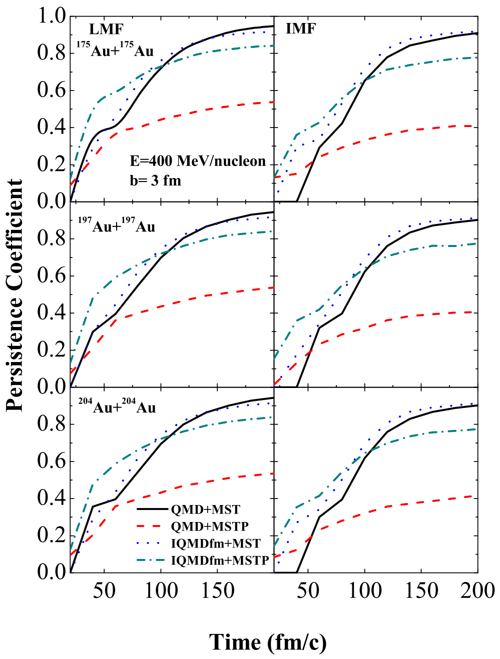

FIG. 1: The Persistence Coefficient for ${}^{175}_{79}Au+^{175}_{79}Au$, ${}^{197}_{79}Au+^{197}_{79}Au$ and ${}^{204}_{79}Au+^{204}_{79}Au$. IQMDfm + MST and IQMDfm + MSTP represents clusterization methods of default IQMD with reduced Fermi momentum. QMD + MST and QMD + MSTP represents clusterization methods of QMD in default version.

two conditions:
(i) Reduction in the Fermi momentum to stabilize the nucleus against fluctuations and to achieve proper binding energy.
(ii) Constraints on the spatial and momentum coordinates to avoid creation of unstable and unbound fragments.
It is clear from the figure that the saturation value of persistence coefficient is slightly higher for LMFs compared to IMFs in both the models [6]. This is because LMFs get separated from the rest of the system much earlier and hence their persistence coefficient saturates much earlier in comparison to IMFs. It has also been observed that phase space obtained from IQMD model when clusterized through both MST and MSTP yield almost same value of Persistence Coefficient for the three isotopes of gold. Similarly, QMD + MST and QMD + MSTP shows clear independence of neutron content of the system and hence give similar value for the stability of the fragments produced through the reactions ${}^{175}_{79}Au+^{175}_{79}Au,^{197}_{79}Au+^{197}_{79}Au,^{204}_{79}Au+^{204}_{79}Au$. Also, on comparing the results obtained from both the models we get reasonable value of persistence coefficient for both light as well as intermediate mass fragments. To conclude,the stability of the final stage fragments produced by any of the two transport models (QMD and IQMD) is independent of the isospin content of the the colliding nuclei.

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