Fragmentation in $^{197}Au +^{197} Au$ collisions: Role of isospin effects

Rajni* and Yogesh K. Vermani
Sri Guru Granth Sahib World University, Fatehgarh Sahib-140406, Punjab (INDIA)

1. Introduction

Recent development in producing energetic radioactive beams has offered an unique platform to investigate isospin effects in the dynamics of nuclear reactions [1]. Multifragmentation and related phenomena occuring in heavy ion collisions are widely studied in literature via statistical and dynamical models [2]. Statistical models ignore the dynamical part and shed light on the final fragment distribution only. On the other hand, in dynamical model, two well defined nuclei collide with each other and produce a piece of hot and dense nuclear matter which remains for a very short span of time and this piece of nuclear matter breaks into light and heavy mass fragments. In the present paper, we studied the dynamics of peripheral and semi central collisions using isospin dependent quantum molecular dynamics (IQMD) model. We also present the results obtained with quantum molecular dynamics (QMD) model to infer the underlying influence of isospin dependent *n-n* potential especially at peripheral geometries.
It would be of interest to study the effect of symmetry potential and coulomb potential via isospin treatment. These potentials are bound to influence density profile, collision rate and final fate of nuclei breaking into large number of fragments.

2. Models

In QMD model, the nucleons of the target and projectile interact via two-body and three-body Skyrme interaction, the Yukawa and Coloumb potentials:

$$\langle V \rangle = V_{Skyrme} + V_{Yuk} + V_{Coul}.$$

The IQMD model, on the other hand, contains isospin degrees of freedom and free pion propagation [3]. Also, coulomb potential V_{coul} takes into account explicit charges of nucleons:

$$\langle V \rangle = V_{Skyrme} + V_{Yukawa} + V_{Coul} + V_{Sym}.$$

Apart from these, isospin and energy dependent cross sections in the collision term and Pauli blocking effects are implemented. Parameters used in these potentials can be found in Ref. [3].

3. Results and Discussion

We simulate the reaction of $^{197}Au +^{197} Au$ at an incident energy of 600 AMeV. The model calculations use *soft* equation of state. Fig. 1 shows the time evolution of heaviest fragment $\langle A^{max} \rangle$ and multiplicities of various fragments at semi-central ($\hat{b}$=0.2) and peripheral ($\hat{b}$=0.8) geometries. In this figure we noticed that in IQMD model, fragments saturate faster so that stable fragments are identified earlier in comparison to QMD model. Cluster consisting of 394 nucleons is formed in IQMD model at 30 fm/c. It signifies that nuclear matter is compressed and there is high density phase *i.e.* all nucleons are bound. But this cluster is unstable. So as time passes, the two nuclei because of their high relative momenta decay further into free nucleons, light charged particles LCPs ($2 \leq A \leq 4$), and intermediate mass fragments IMFs ($5 \leq A \leq 65$). When the impact parameter beween the two nuclei is small then collision rate is enhanced so that fragments are saturated much earlier as compared when the impact parameter between them is large. One can also observe that IQMD model predicts enhanced emission of fragments especially intermediate mass fragments.

In the Fig. 2, we display the mean nucleonic density and collision rate for the same reaction. The nuclear density is closely related to

*Electronic address: rajnibansal.phd@gmail.com

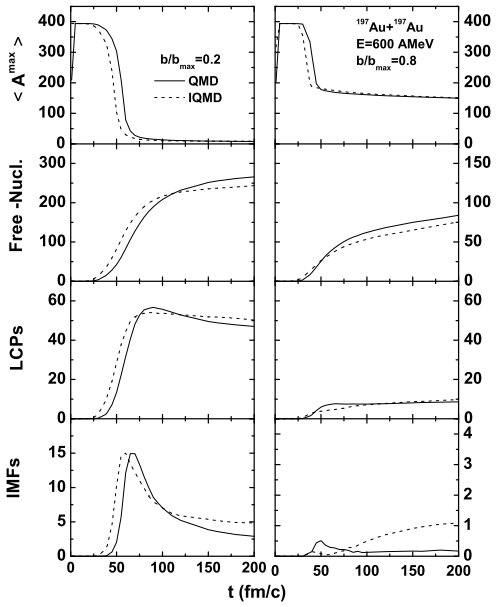

FIG. 1: Time evolution of heaviest fragment $\langle A^{max} \rangle$ and multiplicities of various fragments in $^{197}Au + ^{197}Au$ collision at 600 AMeV.

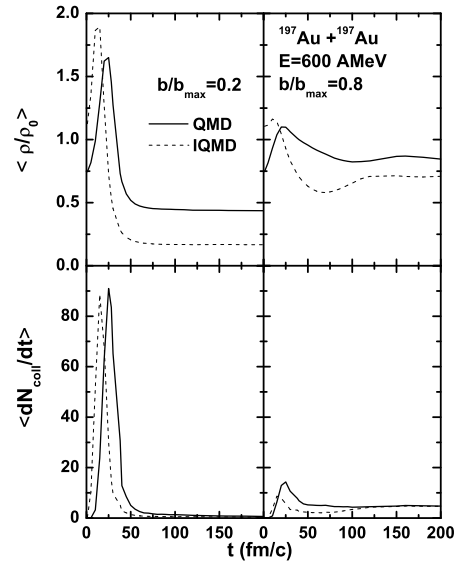

FIG. 2: Mean nucleonic density and the collision rate as a function of time for the same reaction as in Fig. 1.

violence of collision. Violent collisions are active upto 50 fm/c as a result density changes its structure till 70 fm/c. Density saturates much earlier in IQMD model than in QMD model. Further, collision rate depends on the volume of participant zone. For semi central collisions, there is enhanced break up of initial correlations so the collision rate is higher. On the other hand, at peripheral geometry, collisions are less violent.

To conclude, isospin treatment via *n-n* cross-section, symmetry and coulomb potentials has pronounced influence on the dynamics of spectator matter fragmentation. Further study in this direction is in progress.

4. Acknowledgments

This work has been supported by grant from Department of Science and Technology (DST), Govt. of India vide grant no. SR/WOS-A/PS-13/2014.

References

[1] G. F. Peaslee *et al.*, Phys. Rev. C **49**, R2271 (1994); L. Mao, N. Wang and Li Ou, *ibid.* **91**, 044604 (2015); Jian-Ye Liu *et al.*, Phys. Lett. B **540**, 213 (2002).

[2] J. Łukasik *et al.*, Phys. Lett. B **566**, 76 (2003); I. N. Mishustin, Nucl. Phys. A **630**, 111 (1998).

[3] Ch. Hartnack *et al.*, Eur. Phys. J. A **1**, 151 (1998); V. Kaur, S. Kumar and R. K. Puri, Phys. Lett. B **697**,512 (2011).