Influence of density dependent cross-section on charge distribution

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Introduction

The heavy-ion reactions at incident energies between 20 MeV/nucleon and 2 GeV/nucleon provide an opportunity to extract information about the equation of state (EOS) of excited nuclear matter. In a reaction at intermediate incident energy, several observables like multifragmentation, collective flow, subthreshold particle production, elliptic flow, stopping etc. have been reported in the literature [1]. During fragmentation, various intermediate mass fragments (IMFs), light charged particles (LCPs) and free nucleons are emitted. In the last few decades, several experimental groups have carried out complete study of fragment formation with 4π detectors [2, 3]. It is quite obvious that the fragment formation in a heavy-ion collision depends crucially on the bombarding energy and impact parameter of a reaction [2, 3].

We know that the dynamics of a reaction is governed by the mean field (or mutual two- and three-body interactions) and nucleon-nucleon cross-section. At low energies, due to Pauli blocking, the nucleon-nucleon (NN) collisions are almost absent. On the other hand, at higher energies, these nucleon-nucleon collisions become very important. Earlier studies have shown the role of NN cross-section on observables such as transverse momentum, disappearance of flow [4] and fragment formation [5, 6]. For example, in Ref. [6] Kumar and Puri have carried out systematic study of the role different NN cross-sections on fragment formation by employing several different NN cross-sections. This study revealed significant role of cross-section on fragmentation pattern at higher incident energies, in particular at semi-peripheral and peripheral collisions. Similar studies investigating the role of different cross-sections have been done on transverse flow and its disappearance [4]. With the passage of time, reduction factor to the cross-section was proposed that could take care of medium effects. Such studies pointed out that results with $\approx 20\%$ reduction in the cross-section agrees with the experimental data much better compared to that with full cross-section [7]. But we know that the reduction factor should depend on the density of the nuclear matter. In this regard couple of studies have been reported in the literature where one compares disappearance of flow with full cross-section and one with reduced density dependent cross-section [8]. But the studies regarding the role of density dependent reduction cross-section on fragmentation pattern is still missing. Therefore, in the present work, we aim to shed light on this aspect. The present study is carried out within the framework of isospin quantum molecular dynamics IQMD model [9].

Results and discussion

For the present study, we simulated the reaction of ^{40}Ca+^{40}Ca at incident energies of 50 MeV/nucleon and 200 MeV/nucleon with b/b$_{max}$=0.2-0.4. We used soft equation of state with and without momentum-dependent interactions.

The density dependent reduced cross-section has been parameterized as:

$$\sigma = \sigma_{free}(1 - \alpha\frac{\rho}{\rho_0}). \quad (1)$$

The above reactions are simulated by tak-

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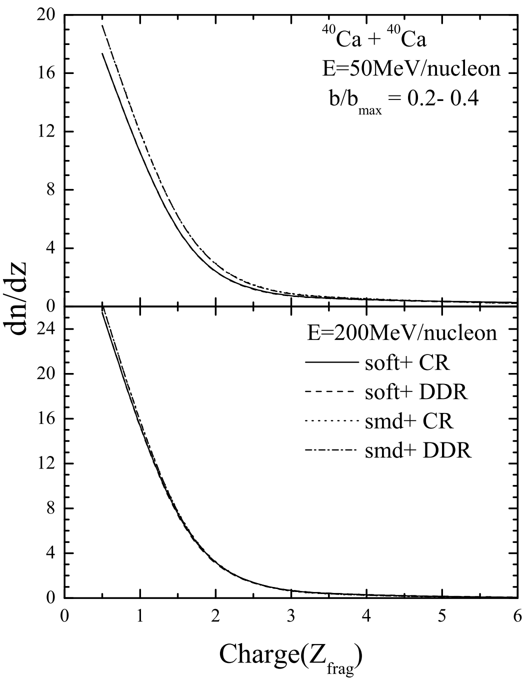

FIG. 1: The charge distribution for ^{40}Ca+^{40}Ca at incident energies of 50 MeV/nucleon (upper panel) and 200 MeV/nucleon (lower panel) (preliminary results).

ing constant reduction in the cross-section by factor of 20% ($0.8\sigma_{free}$, labelled as CR) and one with density dependent 20% reduction (α=0.2, labelled as DDR). As stated in the introduction, the choice of 20% reduction has been motivated by the fact (with soft EOS and MDI) that this parameter set is able to reproduce the measured energies of vanishing flow to the reactions of ^{58}Fe+^{58}Fe and ^{58}Ni+^{58}Ni throughout the colliding geometry [7].

In fig.1, we display the charge distribution for the reaction of ^{40}Ca+^{40}Ca at 50 MeV/nucleon (upper panel) and 200 MeV/nucleon (lower panel). Different lines correspond to different equations of state as well as to different reduction ways of cross-section. The solid and dashed lines correspond to soft EOS with CR and DDR, respectively. Similarly, dotted and dash dotted lines represent the results with SMD EOS with CR and DDR, respectively. From the figure, we notice a linear decrease in the value of charge distribution with charge. The negative slope of charge distribution indicates a gradual transition from the spectator matter to the disassembly of the system.

We also see that charge distribution is insensitive to the reduction scheme at lower incident energies, whereas it is insensitive to both EOS as well as to the reduction scheme at higher energies. These are preliminary results and the detailed study is still underway to look for other observables in the fragmentation pattern in order to pin down the exact role of density dependent reduction of cross-section.

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References

[1] J. Aichelin and H.Stöcker, Phys. Lett. B **176**, 14 (1986); Y. K. Vermani and R. K. Puri, Eur. Phys. Lett. **85**, 62001 (2009).

[2] M. Begemann-Blaich *et al.*, Phys. Rev. C **48**, 610 (1993).

[3] M. B. Tsang *et al.*, Phys. Rev. Lett. **71**, 1502 (1993); D. R. Bowman *et al.*, Phys. Rev. Lett. **67**, 1527 (1991).

[4] D. J. Majestro *et al.*, Phys. Rev. C **61**, 021602(R) (2000); G. D. Westfall *et al.*, Phys. Rev. Lett. **71**, 1986 (1993).

[5] G. Peilert *et al.*, Phys. Rev. C **39**, 1402 (1989).

[6] S. Kumar and R. K. Puri, Phys. Rev. C **58**, 1618 (1998).

[7] S. Gautam *et al.*, J. Phys. G: Part. Phys. **37**, 085102 (2010).

[8] D. J. Majestro *et al.*, Phys. Rev. C **62**, 041603(R) (2000)

[9] C. Hartnack, R. K. Puri, J. Aichelin, J. Konopka, S. A. Bass, H. Stöcker and W. Greiner, Eur. Phys. J. A **1**, 151 (1998).