Effect of different potentials on anisotropic flow

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Introduction

During the last two decades heavy ion collision (HIC) has became the most intensively developing field of nuclear physics to study the nuclear properties. One of the observable used to understand this kind of behavior is collective flow. At low energies, due to the dominance of attractive mean field collective flow becomes negative, which changes to some positive value with the increase in incident energy. The value of intermediate incident energy at which the flow vanishes and attains a 'zero' is called the balance energy (E_{bal}).
In the past few years collective flow and its disappearance has been studied widely[1]. In the present paper we want to study the effect of different potentials on E_{bal} by using IQMD model [2], where the total interaction potential of a HIC is combination of Skyrme potential, Yukawa potential, Coulomb potential, momentum dependent potential and density dependent symmetry potential.
Apart from this, another important observable used to study HIC, which has gathered a lot of interest in the present scenario, is nuclear stopping. Nuclear stopping reveals information about the thermalization and equilibration of the reaction. The degree of stopping vary drastically with incident energy, mass of the colliding system and geometry of the colliding system. J. Y. Liu *et al.* have studied the sensitivity of nuclear stopping towards the isospin dependence of the cross section and found it to be sensitive towards the mean field as well as in-medium nucleon-nucleon cross section [3]. But it should be kept in mind that they have not included the isospin dependence of the medium correction.

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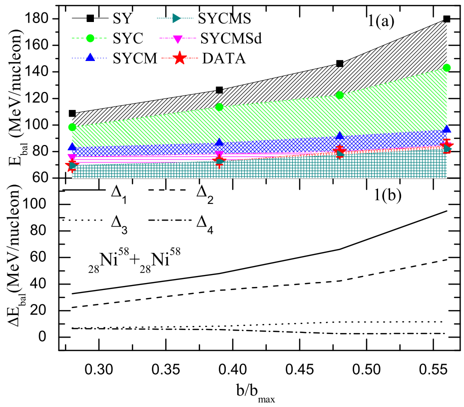

FIG. 1: E_{bal} (a) and ΔE_{bal} (b) as a function of reduced impact parameter for the system $_{28}Ni^{58}+_{28}Ni^{58}$.

We also aim to pin down the effect of different cross-sections on nuclear stopping.

Results

For the present study we simulate thousands of events for the systems $_{28}Ni^{58}+_{28}Ni^{58}$ in the incident energy range between 60 and 140 MeV/nucleon in steps of 20 MeV/nucleon at 200 fm/c. We use a soft equation of state (EOS) with a reduced cross-section $\sigma_{red} = 0.8\sigma_{nn}^{free}$. For the choice of impact parameter, the whole colliding geometry is divided into four bins[4]. We can extract the information about E_{bal} from incident energy dependence of directed transverse flow. Which is defined as

$$\langle P_x^{dir} \rangle = \frac{1}{A}\sum_{i}^{A} sign\{Y(i)\}P_x(i) \qquad (1)$$

where $P_x(i)$ is transverse momentum of i^{th} particle along x direction and $Y(i)$ is the ra-

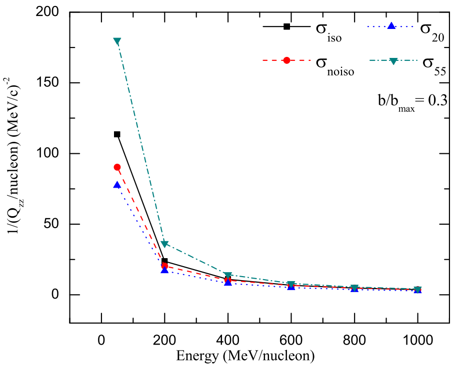

FIG. 2: $1/(Q_{zz}/nucleon)$ as a function of Energy the system ${}_{54}Xe^{131} +_{54} Xe^{131}$.

pidity distribution. $\langle P_x^{dir} \rangle$ is defined over the entire rapidity region. The figure display E_{bal} (fig. 1(a)) and ΔE_{bal} (fig. 1 (b)) as a function of reduced impact parameter for the system ${}_{28}Ni^{58} +_{28} Ni^{58}$. The calculated values of E_{bal} are plotted at the upper limit of each impact parameter bin. Acronym SY stands for Skyrme + Yukawa potential, SYC stands for Skyrme + Yukawa + Coulomb potential, SYCM stands for Skyrme + Yukawa + Coulomb + momentum dependent potential, SYCMS stands for Skyrme + Yukawa + Coulomb + momentum dependence + symmetry potential and SYCMSd stands for Skyrme + Yukawa + Coulomb + momentum dependence + density dependent symmetry potential. Stars represents experimental data and vertical line on data point indicate statistical error. In fig. 1(b) $\Delta_1, \Delta_2, \Delta_3$ and Δ_4 represents the difference between balance energies of SYCMSd and SY, SYCMSd and SYC, SYCMSd and SYCM, SYCMSd and SYCMS respectively. We find that E_{bal} increases as a function of impact parameter for all set of potentials in agreement with the findings of R. Pak *et. al.* [4], and contribution of different potentials result in lowering the E_{bal}. The difference in balance energies between two consecutive sets of potentials gives the contribution of a particular potential. Thus, we conclude that by using IQMD model, addition of different potentials results in achieving the realistic potential, which is able to explain the experimental observations. Fig. 2 depicts the energy dependence of $1/(Q_{zz}/nucleon)$ for the system ${}_{54}Xe^{131} +_{54} Xe^{131}$ at a reduced impact parameter $(b/b_{max}) = 0.3$.

$$Q_{zz} = \sum_i [2p_z^2(i) - p_x^2(i) - p_y^2(i)] \qquad (2)$$

Soft equation of state has been employed with strength of symmetry potential = 32 MeV. We have used a free cross section for the present simulations. To make a comparative study of different cross sections, we have employed an isospin dependent in-medium NN cross section (σ_{iso}), isospin independent NN cross section (σ_{noiso})and constant cross sections of 20 (σ_{20}) and 55 (σ_{55})mb respectively. It is very clear that as increasing the beam energy, nuclear stopping decreases. It is also seen that at low energies, a larger value of constant cross section leads to more nuclear stopping and this effect diminish with the increase in incident energy.

Acknowledgments

This work is supported by the grant from the Department of Science and Technology (DST), Govt. of India [Grant No. SR/S2/HEP21/2010].

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