Interrelation between Energy of Vanishing flow and Transition Energy

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Introduction

The appearance of collective flow is one of the key cognition in heavy ion collisions. Collective flow is of various types like Radial, Directed and elliptical. This collective motion is basically caused by the pressure gradients idiopathic during the time evolution in the collisions. In the present work, we aim to study the interrelation between energy of vanishing flow and transistion energy at different fixed colliding geometries using different radii of initialized nuclei. When both the attractive and repulsive interaction countervail each other at a particular incident energy net flow disappears. This incident energy at which flow disappears is habitually called the Balance energy or energy of vanishing flow (E_{bal}). With increase in incident energy, the elliptical flow shows a transition from positive to negative flow. At a particular incident energy at which transition occurs is called transition energy (E_{Trans}). For the present study, we have used different radius parameterizations as well as liquid drop model (LDM) radius. It has been known that root mean square radius of the charge distribution increases less fast than $A^{1/3}$. In this direction various radii parameterizations have been proposed for the past few decades. The different radius parameterizations of nuclear charge radii, apart from LDM radius are as:

First isospin nuclear charge radii formula proposed by Ngô and Ngô [1] :

$$R_{NGO} = \frac{1}{A}[(1.1375 + 1.875 \times 10^{-4}A^{1/3}) NA^{1/3} + 1.128ZA^{1/3}] \quad (1)$$

This nuclear charge radii formula take isotopic dependence into account.

Another nuclear charge radii parameterized form proposed by Royer and Roussear [2]

$$R_{RR} = 1.2332A^{1/3} + \frac{2.8961}{A^{2/3}} - 0.18688A^{1/3}I \quad (2)$$

IQMD Model

The IQMD model [3] is a semi classical model and an improved version of QMD model [4]. The nucleons of target and projectile interact by two and three body Skyrme forces, Coulomb interactions and Yukawa potential. A symmetry potential between protons and neutrons corresponding to the Betha-Weizsacker formula has also been included. The hadrons propagate using classical Hamiltonian equations of motion, which use to calculate space and momentum co-ordinate of each nucleon after each collision are :

$$\frac{d\vec{r_i}}{dt} = \frac{d\langle\ H\ \rangle}{d\vec{p_i}} \ ; \ \frac{d\vec{p_i}}{dt} = -\frac{d\langle\ H\ \rangle}{d\vec{r_i}} \quad (3)$$

with

$$\langle\ H\ \rangle = \sum_i \frac{p_i^2}{2m_i} + V^{tot} \quad (4)$$

where

$$V^{tot} = V_{Skyrme} + V_{Yukawa} + V_{Coul} + V_{mdi} + V_{sym}$$

$V_{Skyrme}, V_{Yukawa}, V_{Coul}, V_{mdi}, V_{sym}$, respectively, are the local (two and three-body) Skyrme, Yukawa, Coulomb, momentum dependent and symmetric potentials.

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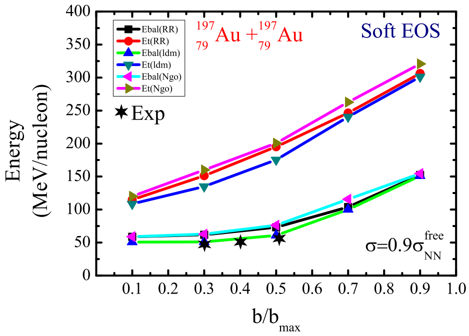

FIG. 1: Interrelation between transition energy and balance energy as a function of Impact parameter using various radius parameterizations, for the symmetric reaction $^{197}_{79}Au +^{197}_{79} Au$

Results and discussion

For the present study, we have simulated the symmetric reaction $^{197}_{79}Au +^{197}_{79} Au$, at an incident energy range between 50 MeV/nucleon to 400 Mev/nucleon and at different fixed colliding geometries.For the present analysis, soft equation of state along with reduce nn cross section $\sigma = 0.9\sigma^{free}_{NN}$ is used.
Our aim is to determine the two entities one is balance energy and other is transition energy. The balance energy and transition energies corresponding to the sideward-flow and squeeze-out effects have been calculated. Balance energy as well as transition energy is found to decrease with the decreasing impact parameters for all the three radius parameterizations. The increase of E_{Bal} and E_{Trans} with impact parameter may pinpoint that the flow issue is cognate to the energy deposited nearby into the overlap zone of the collision, if the local temperature is very high, the generated pressure overcome the attractive nuclear forces. Balance energy and transition energy indeed dependent upon impact parameters. In the central collisions the repulsive pressure is assume to be more favourable and participant matter can expand freely in all directions, while for non central collisions the presence of spectator causes the appearance of sideward-flow and squeeze-out. Our theoretical calculations for Balance energy using liquid drop model are in rather good agreement with the experimental [5] findings. It seems that transition energy is found to be larger than the balance energy for the whole explored impact parameters. There is a interrelation between energy of vanishing flow and transition energy as there differences increases with the increases in the impact parameters.

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