Structural effects in the disappearance of flow

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Introduction

During the last couple of decades, indepth knowledge of the reaction dynamics has been acquired at low and intermediate incident energies. A large number of theoretical dynamical models have been advocated to pin down various phenomena at intermediate energies [1–8]. Broadly, these can be divided into three categories: (i) those based on the one body concept like Boltzmann Uehling Uhlenbeck (BUU) model type [3], (ii) based on the molecular dynamic picture [1, 4] and also (iii) those based on the Fermionic/antisymmetric concept [6]. Though good progress has been made on the dynamical part, clearly no serious attempts are reported on the inputs that enter the calculations via structural effects. Here we shall concentrate on nuclear radius as structural effect [9]. In the literature, many well established potentials used radius of the form $aA^{1/3}+bA^{-1/3}$ [10]. Different values of a and b were chosen to give different parametrizations. Many attempts reported in the literature tried to incorporate isospin effects in the radius [11] and some parametrizations based on proximity potentials also added a constant term in the above formula [10]. The range of radius of ^{12}C using these different parametrizations lies between 2.05 fm (due to Bass [10]) and 2.66 fm (due to Aage Winther (AW) [10]). Note that experimental value of Elton reads as 2.3 fm [12]. At the same time, the radius used in different models at intermediate energies ranges between 2.15 fm (UrQMD) and 2.98

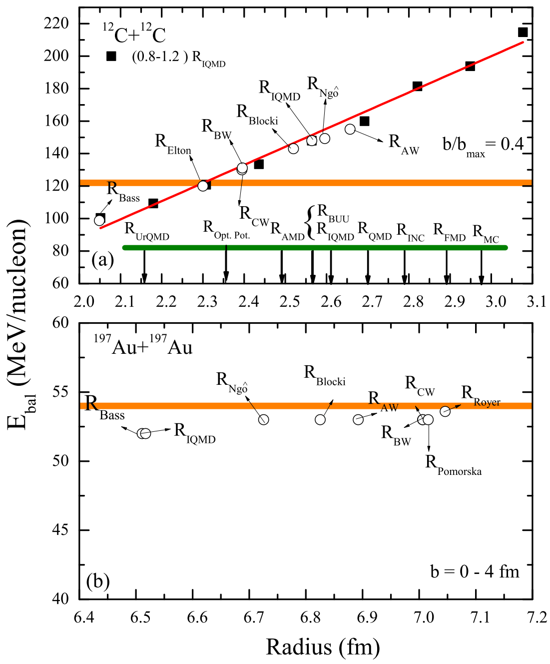

FIG. 1: The balance energy (E_{bal}) as a function of radius.

fm (by MC). The standard liquid drop formula $\propto 1.12A^{1/3}$ leads to radius = 2.56 fm. In contrast, the variation in the radius for ^{197}Au nucleus is far less lies between 6.5 fm (due to Bass [10]) and 7.05 fm (due to Royer [11]) whereas liquid drop model gives 6.52 fm. Note that the effect of different parametrizations will be drastic in the lighter nuclei compare to heavier nuclei where surface contribution is negligible. We shall show that this parameter can play a huge role on the balance energy for the lighter

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nuclei, whereas nearly no effects are seen for heavier nuclei.

Results and discussion

For the present study, we use a soft momentum-dependent (SMD) equation of state with $\sigma = 0.8\sigma_{free}$ and the value of 32 MeV for the strength of symmetry potential using Isospin Quantum Molecular Dynamics Model (IQMD) [1]. We simulated thousands of events for the reactions of ^{12}C+^{12}C and ^{197}Au+^{197}Au at impact parameter of b/b$_{max}$ = 0.4 and b = 0 - 4 fm (as guided by the experimental findings [13, 14]), respectively at incident energies between 40 MeV/nucleon and 200 MeV/nucleon at a step of 10 MeV/nucleon. As stated, we took different radii in IQMD model and then computed the balance energy (E$_{bal}$).

In fig. 1, we display the balance energy calculated using different parameterizations of radius for the reaction of ^{12}C+^{12}C (upper panel). A straight line interpolation method is used to calculate the balance energy in each case. The solid squares represent the E$_{bal}$ by varying radius systematically between 80% to 120% of the IQMD model. This covers all the radius range (2.15 to 2.98 fm) used by various dynamics models at intermediate energies. The open circles represent the calculated energies of vanishing flow using different radius parametrizations and also include the measured one due to Elton [12] (as has been labelled). We see that the balance energy increases with increase in the radius. This is due to the decrease in the strength of repulsive forces with radius, thus diminishing the collective flow and therefore pushing the balance energy towards higher side. To see the effect of radius on the heavier system, we also display the balance energy for the reaction of ^{197}Au+^{197}Au (lower panel) using different parametrizations of radius. In contrast to ^{12}C case, we see that E$_{bal}$ remains almost constant, thus demonstrating an insignificant dependence. The thick solid horizontal line represents the experimentally measured E$_{bal}$ for the reactions of ^{12}C+^{12}C and ^{197}Au+^{197}Au. From the figure, it is evident that the balance energy is significantly affected by the radii of colliding nuclei for the reaction of ^{12}C+^{12}C compared to ^{197}Au+^{197}Au. Different parametrizations yield E$_{bal}$ between 50-54 MeV/nucleon and 98-155 MeV/nucleon for the reactions of ^{197}Au+^{197}Au and ^{12}C+^{12}C, respectively. Note that an increase of $\backsim$ 30% in radius results $\backsim$ 58% change in the E$_{bal}$ for the ^{12}C+^{12}C system, whereas $\backsim$ 8% change in the radius for ^{197}Au+^{197}Au system, results only $\backsim$ 3% change in the balance energy. Therefore, the study demonstrates that the lighter system like ^{12}C+^{12}C is very sensitive to the choice of radius, whereas heavy nuclei like ^{197}Au are less sensitive.

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