Experimental and simulation results for isoscailng of a reconstructed quasi-projectile

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To determine if experimental data follows the trends of an asy-stiff or asy-soft equation of state (EoS), and to probe the effects of the asymmetry energy, experimental data is often compared with theoretical predictions. This work compares observables from experimental reactions to results from several dynamical and statistical models. Isoscaling analysis [1] was carried out on the experimental and simulated data, both before and after a QP reconstruction. Quasi-projectile (QP) reconstruction is also performed for the experimental and theoretical data [2].

Charged particles and neutrons from the reactions of ^{70}Zn+^{70}Zn, ^{64}Zn+^{64}Zn, and ^{64}Ni+^{64}Ni at 35 MeV/A were detected in the NIMROD-ISiS array [3]. These reactions were also simulated using anti-symmetrized molecular dynamics (AMD) [4] and constrained molecular dynamics (CoMD) [5,6]. AMD simulations were run out to 300 fm/c, the results of which were then de-excited by the GEMINI statistical model [7]. The AMD and CoMD models were also run to a final time of 3000 fm/c to allow the fragments to de-excite dynamically. To compare the simulated results to experimental results, the simulation data was run through the same filter as the experimental data.

Isoscaling analysis is performed comparing each pair of neutron-rich to neutron-poor systems, for a total of three ratios. For each element in isoscaling, a linear fit is constructed through all of its isotopes. The slope of this fit is the isoscaling parameter, α , and is proportional to the asymmetry energy. Each element has a separate slope, so to provide a single α value for each isoscaling analysis, a global fit of the isoscaling data was performed that includes the two parameters of the isoscaling equation, the chemical potential of the neutrons and protons, α and β [1]. Using this fit, a single parameter, α, can be extracted to describe the isoscaling of two systems. Due to the difference in the N/Z of each of the systems, the resulting isoscaling parameter, α, depends on the two systems being used in the isoscaling ratio. To compare all of the systems together, a parameter of the asymmetry of the system is used to take into account the changing of α with the system. The value of Δ has been used to calculate the difference in the asymmetry of the fragments in the two sources used for the isoscaling ratio[8]. Relating the α from isoscaling to the Δ of the systems used in isoscaling gives us a way to compare not only each of the experimental points, but also the simulated data to the experimental data. This isoscaling analysis was first performed on system-to-system comparisons using the above reactions. A QP was then reconstructed from the simulation and experimental data and isoscaling was performed on the QP using the same technique as Wuenschel [2]. The QP reconstruction has been shown to improve the fit of the isoscaling [2]. This improvement is due to the improved definition of the systems used for the isoscaling ratio. The QP source is used as the source of the fragments in the isocaling ratio instead of the entire system. The results from the QP isoscaling are shown in Fig. 1.

Fig. 1 shows the plot of the global isoscaling parameter, α, vs. fragment asymmetry, Δ, for QP reconstruction results of theoretical simulations and experiment for one isoscaling comparison. The diagonal lines are fits to the results of the simulations, forced through the origin, where the slope of the

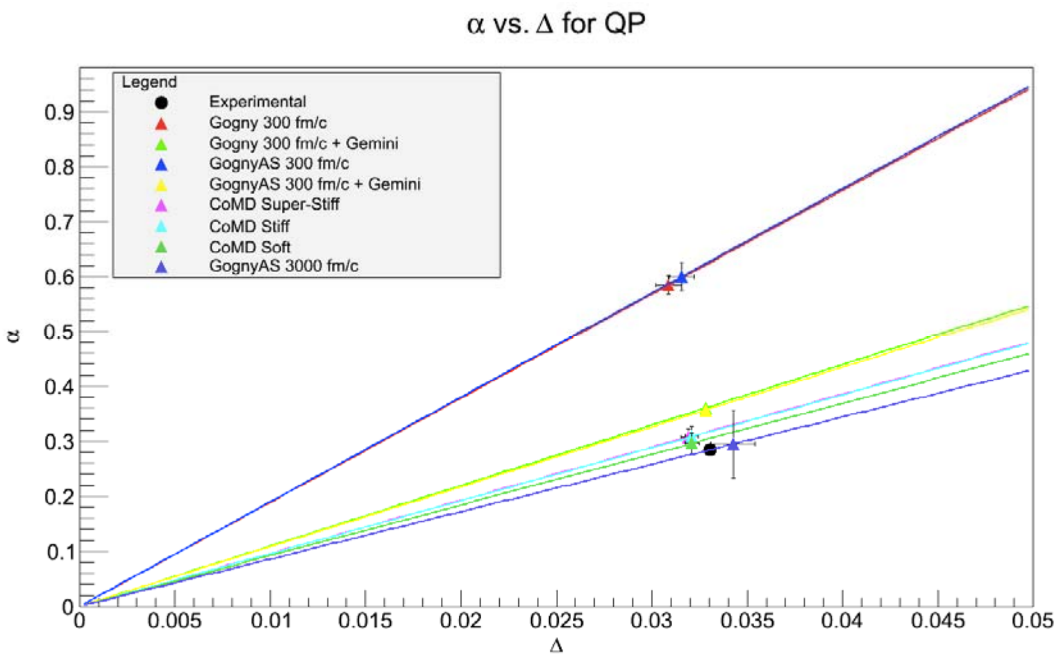

FIG. 2. Plot of global isoscaling parameter, α, vs. fragment asymmetry, Δ, for one isoscaling ratio from a reconstructed QP.

isoscaling is zero when a system is compared against itself. Lines are used to represent the relationship between α and Δ since they are linearly related, and changing the difference in asymmetry of the sources changes the isoscaling. For the QP reconstructed results, the experimental data matches reasonable to the AMD simulations at 300 fm/c with GEMINI, as well as the simulations at 3000 fm/c. The AMD at 300 fm/c has a larger α value than the simulations at longer time-steps, as well as the results from GEMINI. This suggests that the slope of isoscaling decreases over time.

Figure 2 shows how the α parameter from isoscaling changes with time

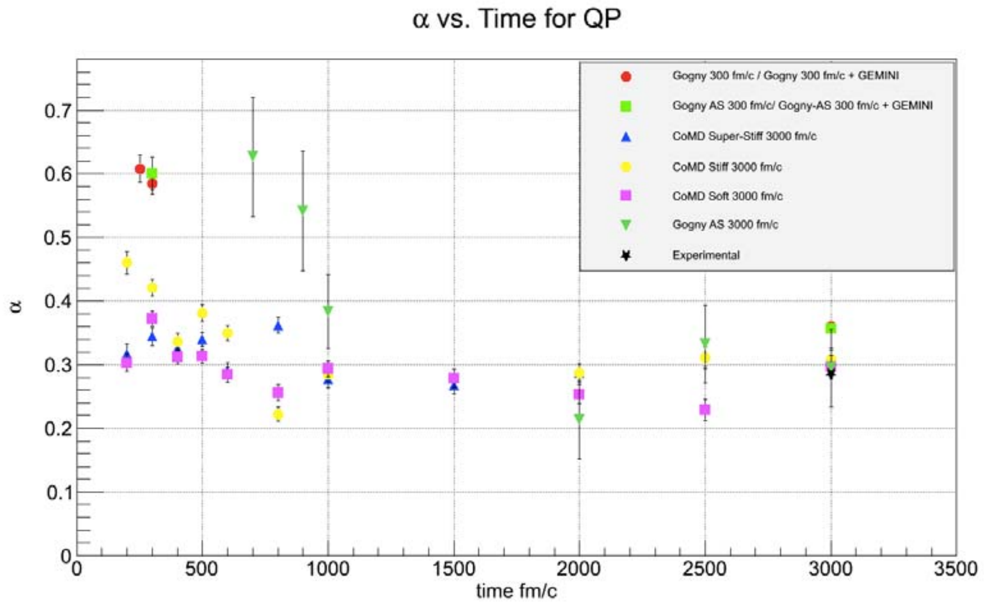

FIG. 1. Plot of global isoscaling parameter, α, vs. time for QP reconstruction of AMD and CoMD. The results of AMD at 300 fm/c with GEMINI are plotted at 3000 fm/c.

The AMD simulation at 300 fm/c has a larger α value than at 3000 fm/c or at 300 fm/c with GEMINI. In general, the α value from the simulations decrease over time. This result matches the results from the α vs. Δ plots where the α decreases with time.

The results from isoscaling show a large dependence on the time of the simulation when compared to the experimental results, but do not suggest an asymmetry energy dependence in the comparison. Also, the results from AMD at 3000 fm/c match well with the results from AMD at 300 fm/c with GEMINI in the isoscaling analysis, suggesting that the type of de-excitation in the simulation, statistical or dynamical, does not affect the results of the analysis.

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