Studies on antisymmetrized molecular dynamics (AMD) and isoscaling

A. Raphelt, Z. Kohley, P. Cammarata, P. Marini, L. W. May, A. McIntosh, and S. J. Yennello

Isoscaling was performed on nuclear collisions of ^{70}Zn+^{70}Zn and ^{64}Zn+^{64}Zn at 35 MeV/A from experimental data and from simulations by antisymmetrized molecular dynamics (AMD). The AMD model has two forms, the Gogny and the Gogny-AS. At high densities, the symmetry energy of the Gogny force decreases while the Gogny-AS force increases. AMD was simulated for various reactions for 300 fm/c for both forces, and up to 3000 fm/c for the Gogny-AS force. After 300 fm/c, Gemini was applied to AMD in order to de-excite the fragments. For the AMD data, all events were used in the isoscaling. For the experimental data, all events with isotopic identification and multiplicity greater than two were used. All isotopes of elements through sulfur were used in isoscaling and only central collisions were studied except where indicated. In isoscaling, the parameter α, related to the neutron content of the fragmenting source, can be extracted. A plot was made to show the change of the α parameter with impact parameter. The impact parameter can be extracted from the AMD simulations and was approximated by Kohley for his experimental data. The α parameter was extracted from the isoscaling of the ^{70}Zn+^{70}Zn/^{64}Zn+^{64}Zn. Here it can be seen in Figure 1 that as the impact parameter increases, the α parameter also increases.

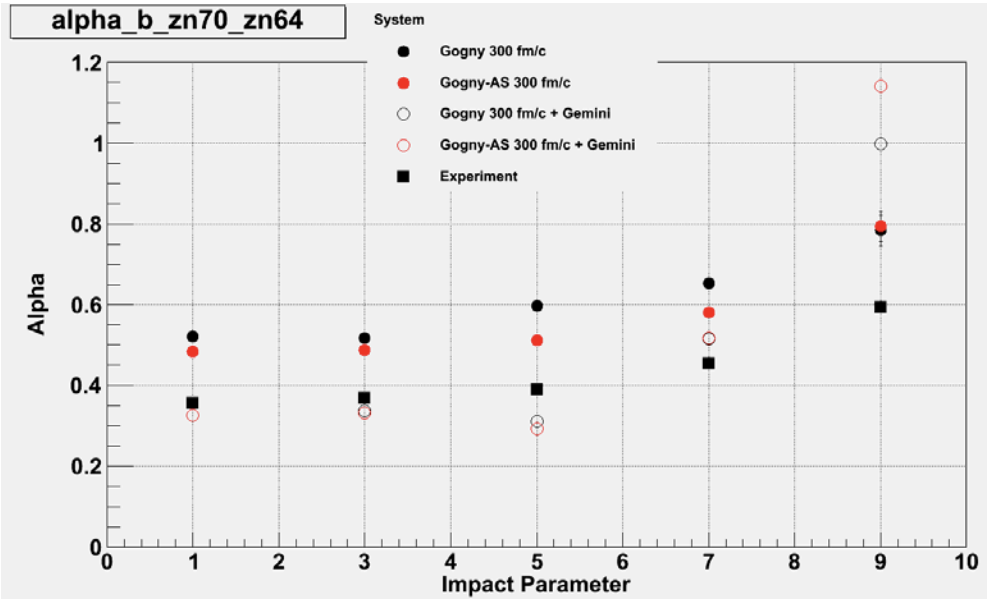

FIG. 1. The α parameter vs. impact parameter.

A plot of excitation energy vs time is shown in Figure 2 in order to look at the change in excitation energy of the fragments from the reaction as it progresses in time. The Gogny-AS form of AMD was simulated for the reaction of ^{70}Zn + ^{70}Zn from 0 to 3000 fm/c. The excitation energy of the experimental reaction was calculated as the sum of the excitation energy of the fragments. The excitation energy was plotted by splitting the fragments from the reaction into various groups based on their charge.

Fig. 2 shows that as the reaction proceeds to 3000 fm/c, the excitation energy for the reaction decreases initially, but then reaches a plateau at some E*/A value for each fragment size. This is interesting because by 3000 fm/c, the reaction should be complete and fragments should have cooled through de-excitation channels so that there is no excitation energy left. The AMD model does not seem to show the fragments de-exciting completely.

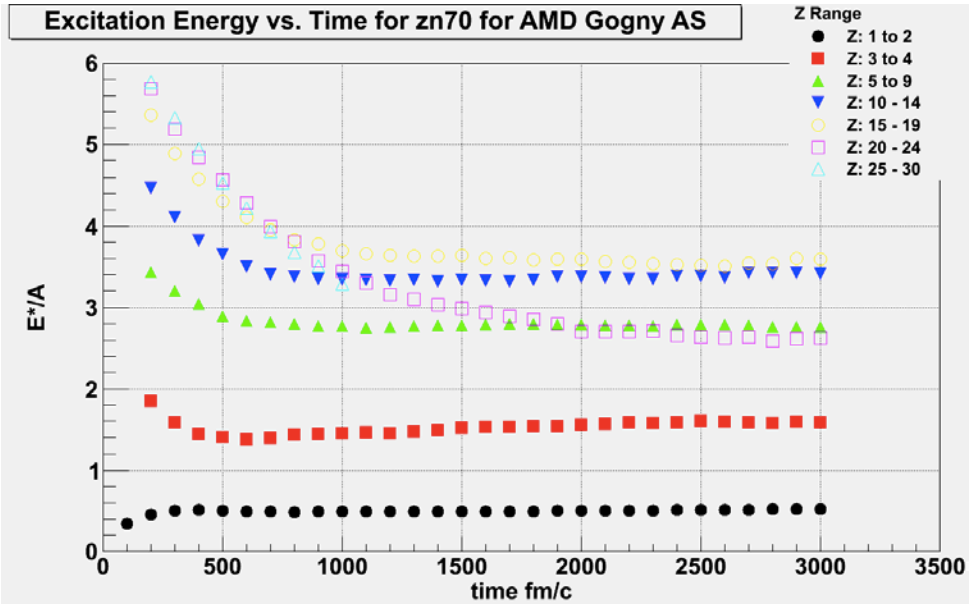

FIG. 2. Excitation energy vs. time.

Figure 3 shows how the isoscaling parameter, α, from the system of ^{70}Zn+^{70}Zn/^{64}Zn+^{64}Zn changes as a function of time. Values of α for AMD are shown along with the values from a simulation

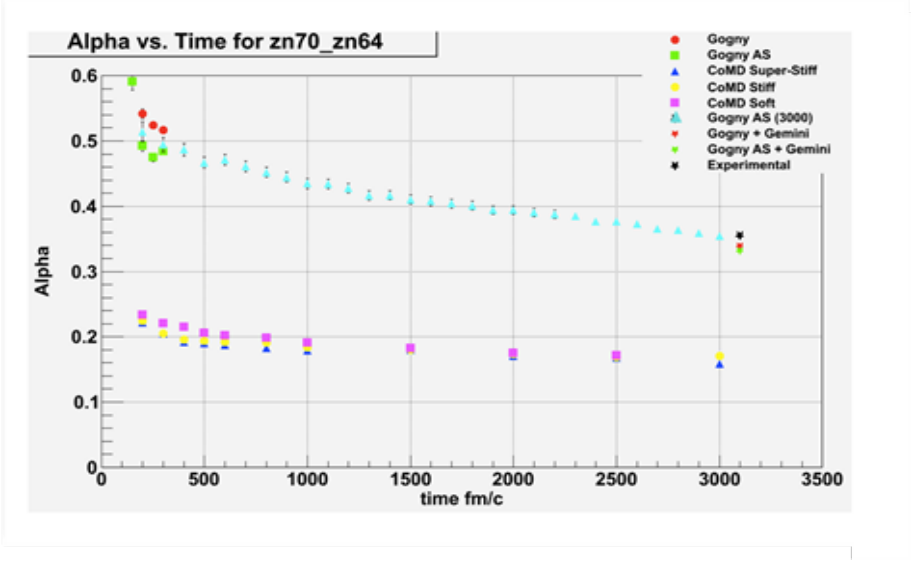

FIG. 3. The α parameter vs time.

using constrained molecular dynamics (CoMD). The experimental data and the AMD data with Gemini

applied are plotted at 3100 fm/c in order to position them after the final time-step of the simulated data. In this plot, the AMD Gogny-AS values decrease with time and approach the same final α value as the experimental data. Also, the AMD with Gemini data lie very close to the experimental point as well. This agreement between the model and the experimental values of α indicates the utility of isoscaling on AMD simulated data.

[1] A. Ono *et al.*, Phys. Rev. C **68**, 051601 (2003).
[2] D.V. Shetty *et al.*, Phys. Rev. C **70** 011601(R) (2004).