N/Z equilibration in the quasi-projectile of Ar, Ca+Sn reactions: experimental and simulation comparisons

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Experimental values of N/Z equilibration were calculated by the method developed by A. Keksis [1]. The isobaric yield ratios for the A=3,6,7,11,14,16 isobars were calculated from reactions of ^{40,48}Ca beams on ^{112,124}Sn targets. These isobar yield ratios were then plotted individually versus the N/Z of the quasi-projectile (QP) for the four systems. The $(N/Z)_{QP}$ was assumed to be a straight mixing between the initial target and projectile N/Z such that:

$$\frac{N}{Z}_{QP} = X * \frac{N}{Z}_{target} + Y * \frac{N}{Z}_{projectile}$$

The $(N/Z)_{QP}$ was varied and the value that gave the most linear fit through the four systems was assumed to be the N/Z value for the resulting QP. A "percent equilibrium" is defined as the change in the $(N/Z)_{QP}$ value between that of the initial projectile N/Z and the composite system N/Z. This method makes the assumption that N/Z equilibration has occurred when the entire system has reached the N/Z of the composite system and that each piece (quasi-projectile and quasi-target, QT) retains the N/Z of the equilibrated (composite) system.

Calculations performed with the iBUU (isospin-dependent Boltzmann-Uehling-Uhlenbeck) transport code [2] on the same systems were then analyzed to determine the $(N/Z)_{QP}$ from the code. The iBUU output gives test particle positions, momentum and identity (proton or neutron, originally target or projectile) at the moment the code ends. This information was used to locate the high-density center of the QP and a spherical geometry cut was applied in order to define a quasi-projectile. The test particles with the geometry cut were then used to calculate an N/Z value for the QP. The iBUU calculations were performed at impact parameters of b = 5,6,7,8,9 and 10 fm, and each was completed for two parameterizations of the equation-of-state (EOS), x=0 and x=-1. Since the experimental impact parameter distribution is not known, the $(N/Z)_{QP}$ values for the 6 impact parameters from iBUU were averaged together and used for comparison to the data.

Fig. 1 shows a comparison of the experimental and theoretical results. The y-axis is the N/Z value of the different results scaled by the N/Z of the composite system. Therefore, the composite system N/Z is set at 1 across the plot. The projectile and target N/Zs are shown for reference for each system. Experimental data is shown for two separate beam energies, 32 MeV/u and 45 MeV/u. Similarly, the iBUU results are shown for two beam energies as well as two parameterizations of the EOS. It can be seen that for the two systems with ^{40}Ca as the projectile, the theoretical results match rather closely with the experimental results and that a slight difference can be noted between the different beam energies and different EOS. However, the iBUU results for the ^{48}Ca systems vary noticeably from the experimental. The experimental and theoretical results are in some agreement but additional work is needed in order to understand the differences that are seen.

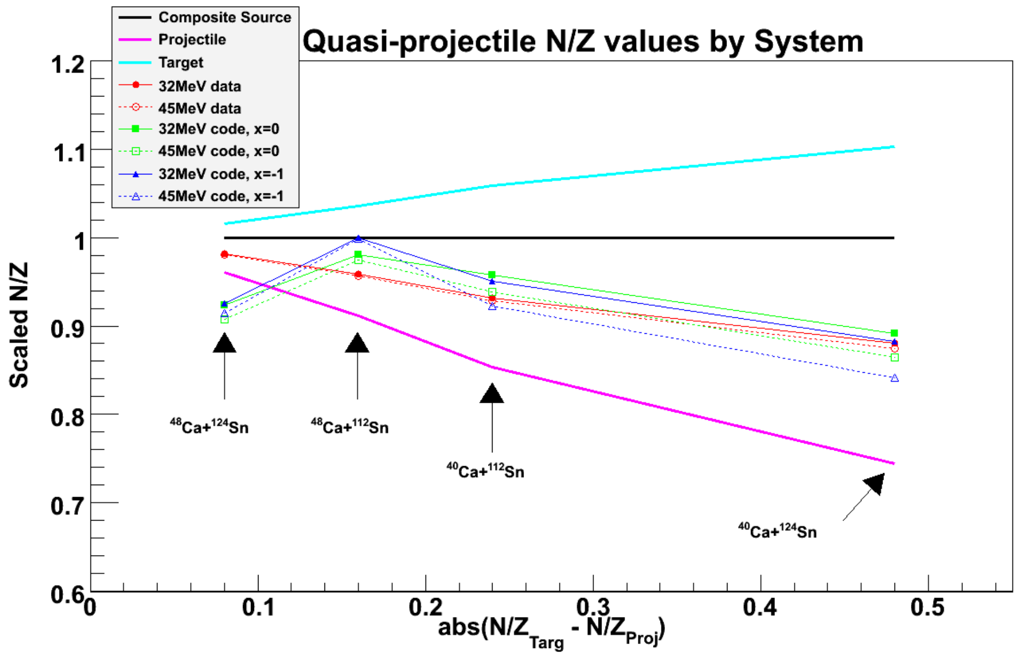

FIG. 1. Quasi-projectile N/Z scaled to the composite system N/Z (assumed to be equivalent to a fully N/Z equilibrated system) as a function of the absolute difference in N/Z between the initial projectile and

Further work would seek to include the Ar projectile systems as well as the inclusion of x=1 and x=-2 parameterizations of the EOS in iBUU calculations. Also, to better deal with the issue of unknown experimental impact parameter distribution, work could be done using the codes to correlate QP velocity to impact parameter. This result could then be used on the experimental data so that experimental QP velocities would determine a rough idea of the impact parameter distribution in the data.

[1] A. Keksis. Ph. D. Thesis, Texas A&M University, 2007.

[2] Li *et al*., Phys. Rev. C **69**, 011603 (2004).