Reaction Tomography at 47A Mev

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We are investigating the dynamics and thermodynamics in light ion and heavy ion collisions near the Fermi Energy by comparing the yields, spectra and angular distributions of observed products from different reaction systems at same incident energy. A large series of heavy ion reaction systems have been studied with NIMROD. They include

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\begin{align*}
&\text{1} \text{H} + \text{112Sn} \quad \text{1} \text{H} + \text{124Sn} \\
&\text{2} \text{H} + \text{112Sn} \quad \text{2} \text{H} + \text{124Sn} \\
&\text{3} \text{He} + \text{112Sn} \quad \text{3} \text{He} + \text{124Sn} \\
&\text{4} \text{He} + \text{112Sn} \quad \text{4} \text{He} + \text{124Sn} \\
&\text{10} \text{B} + \text{112Sn} \quad \text{10} \text{B} + \text{124Sn} \\
&\text{20} \text{Ne} + \text{112Sn} \quad \text{20} \text{Ne} + \text{124Sn} \\
&\text{40} \text{Ar} + \text{112Sn} \quad \text{40} \text{Ar} + \text{124Sn} \\
&\text{64} \text{Zn} + \text{112Sn} \quad \text{64} \text{Zn} + \text{124Sn}
\end{align*}
\]

all with the same incident energy, 47 Mev/A.

In our data analysis, we expect to be able to separate emission resulting from nucleon-nucleon collisions from that resulting from the thermalized system and obtain a much cleaner picture of the dynamic evolution of the hotter systems. This series of experiments provides us an opportunity to probe temperature evolution, in-medium nucleon-nucleon cross sections, isospin effects, and symmetry energy by creating similar systems with different densities and different N/Z ratios in the interaction region [1-3, 5, 6].

A common technique i.e Three Source Fitting has been used to fit the observed spectra assuming contributions from three sources, a projectile like fragment (PLF) source, an intermediate velocity (NN) source, and a target like fragment (TLF) source. This allows us to characterize light particle emission and provides us a schematic picture of the emission process and estimation of the multiplicities and energy emission at each stage of the reaction [4].

In our approach, we select the most violent events by taking into account only the events with the 30\% largest light particle multiplicity. In Figure 1 below are the velocity plots of p, d, t, 3He, 4He from \(^{10}\text{B} + ^{124}\text{Sn}\), \(^{64}\text{Zn} + ^{112}\text{Sn}\), \(^{64}\text{Zn} + ^{124}\text{Sn}\) respectively.

From these velocity plots, we can see that emission in the different systems looks qualitatively similar but the intensities are quite different.
Figure 1. Velocity plots of $^1\text{H}$, $^3\text{He}$, $^4\text{He}$ emission from $^{10}\text{B} + ^{124}\text{Sn}$, $^{64}\text{Zn} + ^{112}\text{Sn}$ and $^{64}\text{Zn} + ^{124}\text{Sn}$

Figure 2. (Left) $\tau/^3\text{He}$ ratios at mid-rapidity. (Right) $^{64}\text{Zn}$ temperatures.
We also generated plots of $t/^{3}\text{He}$ ratios and $^{64}\text{Zn}$ temperatures from source fitting parameters at mid-rapidity $V_p$ 5-6 cm/ns. These are in Figure 2 and show that the $t/^{3}\text{He}$ ratios are different, reflecting the different N/Z in the system. Double isotope ratio temperatures, $T_{\text{HHe}}$, are very similar. Further analyses are under way.