Dynamical Fragment Formation In CoMD Simulations

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Motivation

Previous experimental measurements have been made demonstrating a relationship between fragment alignment (α) and composition (Δ) in heavy ion collisions. It is proposed that the post-collision excited dinuclear projectile-like-fragment (PLF*) rotates for some time until it dynamically splits into two fragments (a lighter fragment, LF, and a heavier fragment, HF) at which point neutron-proton equilibration and rotation would simultaneously cease. This mechanism implies a relationship between these fragments' angular alignment, composition, and contact time (t_c). The intent of this research is to test the extent of these relationships and compare simulated results to observable quantities in experimental data. [3, 6, 7, 2, 1]

Method of Study

- Constrained Molecular Dynamics (CoMD) [4, 5]
- 35 MeV/u ^{70}Zn+^{70}Zn collisions
- Event Trees (Visualization and Analysis)
- Calculated Animations (Visualization)

Mathematical Definitions

- **Alignment:**
  $|\overrightarrow{v_{cm}}||\overrightarrow{v_{rel}}|\cos\alpha = \overrightarrow{v_{cm}} \cdot \overrightarrow{v_{rel}}$
  - $\overrightarrow{v_{rel}} = \overrightarrow{v_{HF}} - \overrightarrow{v_{LF}}$
  - $\overrightarrow{v_{CM}}$ is the center of mass velocity of HF and LF
- **Average Composition:**
  $\langle\Delta\rangle = \langle\frac{N-Z}{A}\rangle$

Visualization Techniques

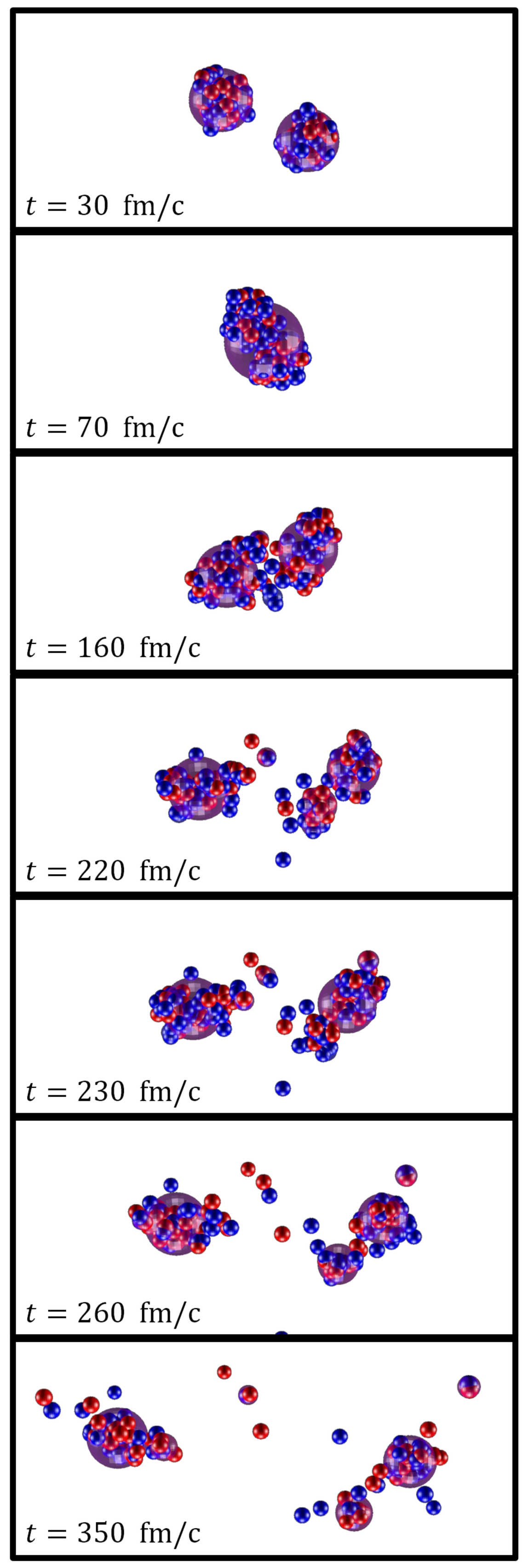

Figure 1: Animated ^{70}Zn+^{70}Zn collision at 35 MeV/nucleon corresponding to the same event as the tree on the right Nucleons: Protons (red) and neutrons (blue) are drawn with the clustering radius 2.76 fm. Fragments: Drawn with transparent spheres

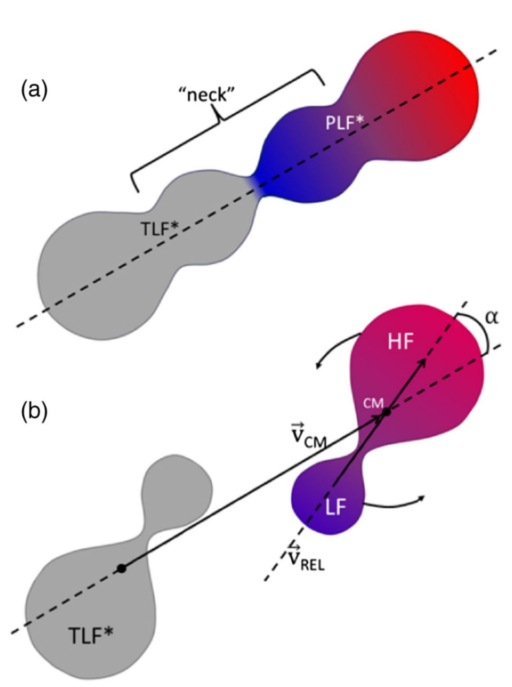

Figure 2: Definition of anglular alignment, α [3]

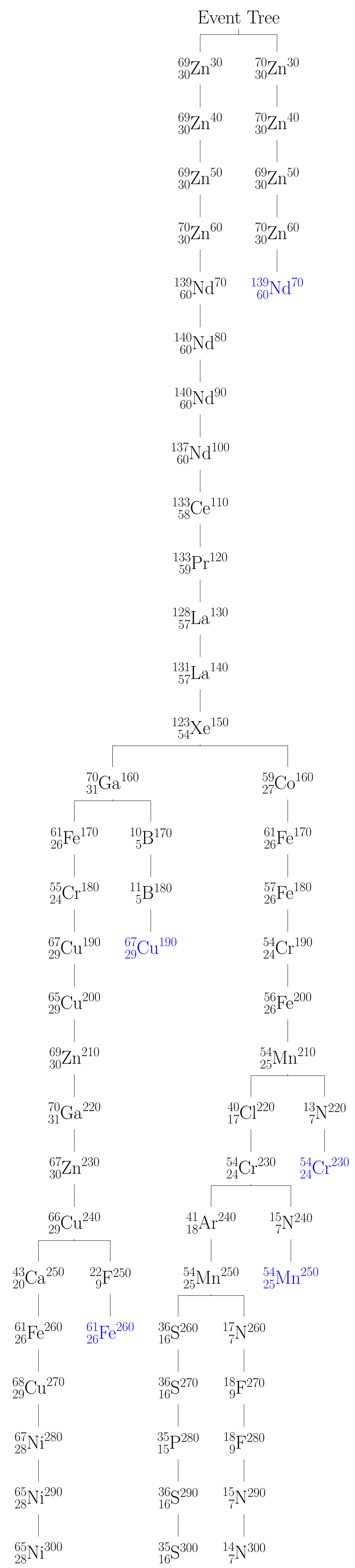

Figure 3: Event tree reconstructs events based on each fragments' daughters in the following time step. Blue lettering indicates fragment merging by sharing a daughter. The time in fm/c is super-scripted on each isotope.

Contact Time and Fragment Alignment

- Competing Statistical (Isotropic Background) and Dynamical Processes (Time-Related Peak)
- For $t_c > 150$ fm/c a roughly linear correlation to average alignment angle is shown

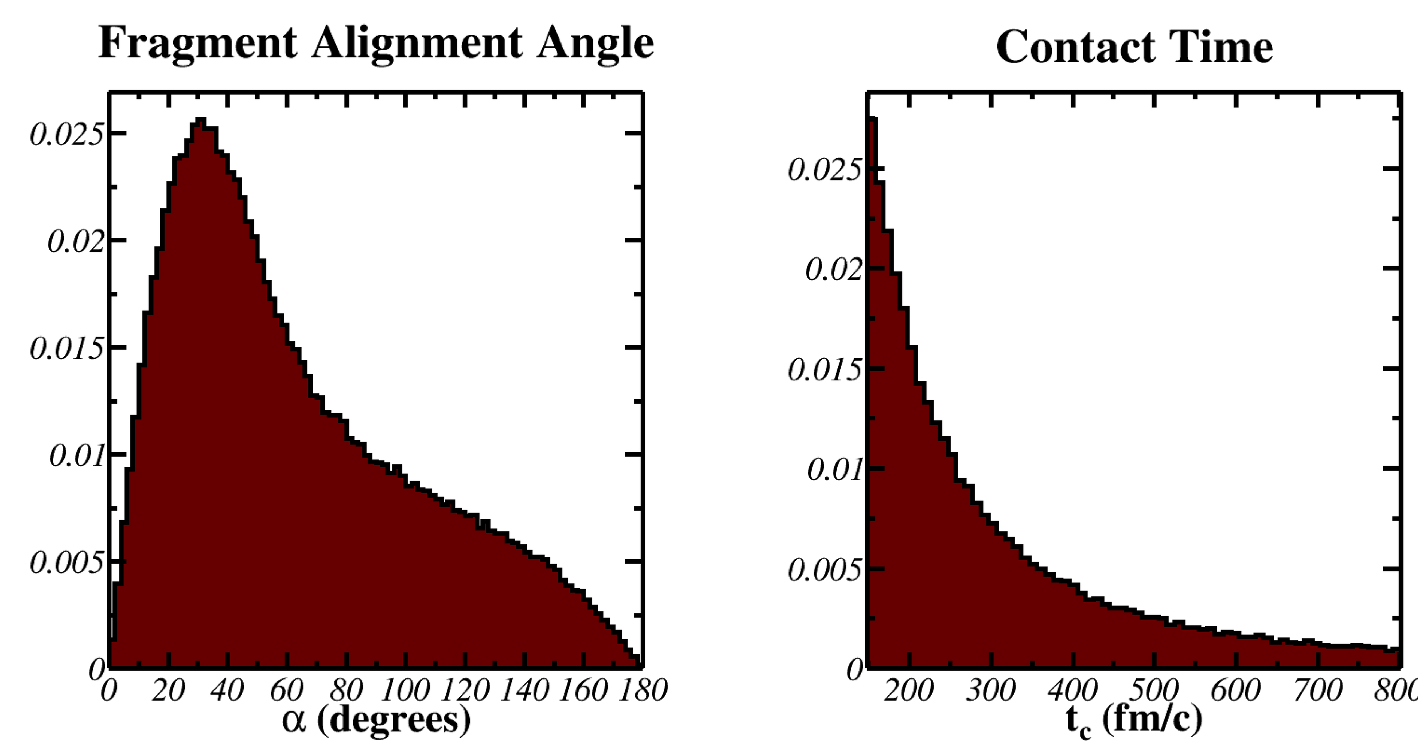

Figure 4: (left) Relative yield distribution of α for events with $Z_{LF} = 4$. A prominent dynamical peak is shown in addition to the isotropic region. (right) Relative yield distribution for contact time

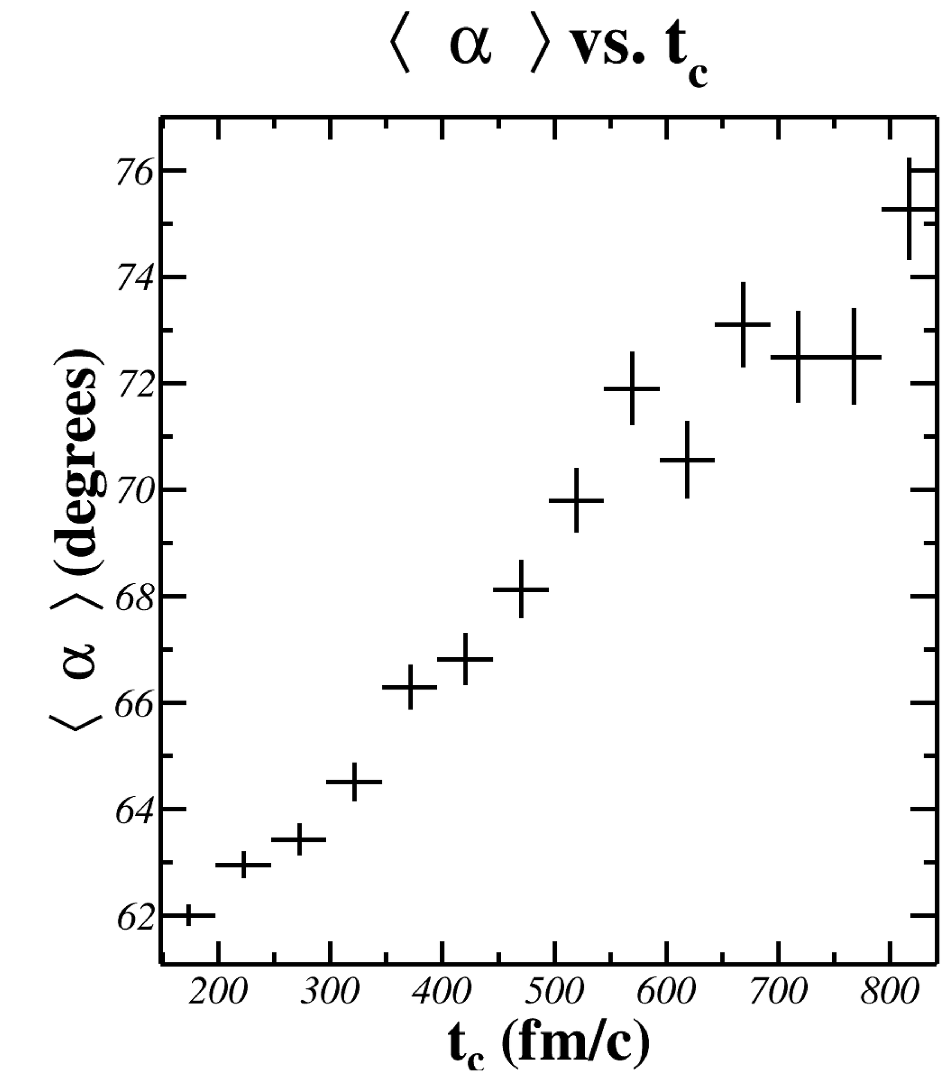

Figure 5: A correlation between average alignment and contact time

Timescale of Neutron-Proton Exchange

Because a relationship appears to exist between average alignment and contact time, it is reasonable to check each quantity's relationship with the average composition of the light fragment. We see similar trends in each plot (shown on right for $Z_{LF} = 4$) supporting the existence of the proposed breakup mechanism.

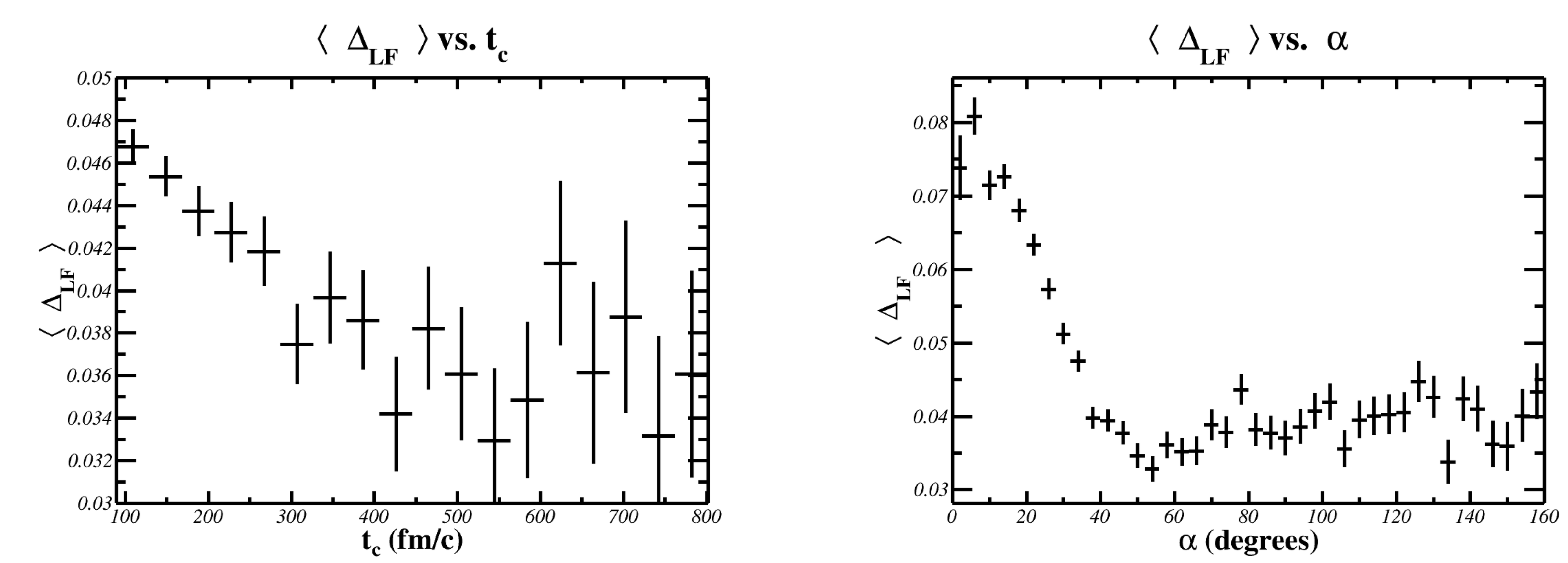

Figure 6: Average Light Fragment Composition as a function of contact time (left) and alignment (right)

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