Tracking saddle-to-scission dynamics using N/Z in projectile breakup reactions

SYLVIE HUDAN

April 1, 2012
Dynamical Breakup

Observation of strongly aligned decay in mid-peripheral collisions at intermediate energies with:

* Large yield
* Large relative velocity relative to fission

Montoya et al., PRL73, 3070 (1994); Bocage et al., NPA676, 391 (2000)
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S. Hudan et al., PRC71, 05402 (2006)
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$^{124(,136)} \text{Xe} + ^{112, 124} \text{Sn} @ 49.2 \text{ MeV/A}$

Experiment performed at GANIL (France)

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- **LASSA: 36.4^\circ \leq \theta_{\text{Lab}} \leq 51.5^\circ**
- **DEMON: n TOF**

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Aligned Decay

Angle between the relative velocity and the fragment “parent” velocity
**Aligned Decay**

- Asymmetric angular distributions
- Larger asymmetry for lighter $Z_L$
- Asymmetry persists up to $Z_L = 18$
- Similar yield for n-rich target

Angle between the relative velocity and the fragment “parent” velocity

$\cos(\alpha)$

$Z_L = 4$  
$112^{\text{Sn}}$  
$Z_L = 6$  
$124^{\text{Sn}}$

$Z_L = 8$  
$Z_L = 14$

$_{\text{c.m.}}$  
$\vec{V}_{\text{REL}}$

*: Backward enhancement observed in Sn+Ni for change of target and projectile

P. Russotto *et al.*, PRC 81, 064605 (2010)
Isotopic Composition vs Rotation Angle

• Backward emission neutron-rich relative to forward emission
• Fragment neutron content enhanced for larger alignment
• No visible target effect of the relative neutron composition
Relative Velocity Dependence

- $Z_L = 4$
- $Z_L = 5$
- $Z_L = 6$
- $Z_L = 8$

$\langle N/N \rangle$ vs. $v_{REL} (\text{cm/ns})$

- $0^\circ$-$37^\circ$
- $37^\circ$-$66^\circ$
- $66^\circ$-$90^\circ$
- $90^\circ$-$180^\circ$
Relative Velocity Dependence

- $\langle N \rangle / Z$ decreases with $v_{\text{REL}}$ for forward decay (Coulomb effect)
- $\langle N \rangle / Z$ increases with $v_{\text{REL}}$ for backward decay
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More aligned decay with higher $v_{\text{REL}}$ ⇒ observed angular dependence
Time Extraction

t = 0
Time Extraction

- The rotation angle can be related to time via the rotational frequency $\omega$:

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$$v_{REL} \Rightarrow \text{angle} \Rightarrow \text{time}$$

$^*$: G. Casini et al., PRL 71, 2567 (1993)
N/Z Time Dependence

\[ \langle N \rangle / \langle Z \rangle = \begin{cases} 1.3 & Z_L = 4 \\ 1.22 & Z_L = 5 \\ 1.21 & Z_L = 6 \\ 1.12 & Z_L = 8 \end{cases} \]

- 0°-37°
- 66°-90°
- 37°-66°

1 zs = 10^{-21} s
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  - Similar dependence for both short and long times
Conclusions
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- The $\langle N \rangle/Z$ of fragments emitted in dynamical decay is correlated with the rotation angle.
- Different $v_{\text{REL}}$ dependence are observed for forward and backward emission.
- For backward decays, $\langle N \rangle/Z$ increases with $v_{\text{REL}}$ with a similar magnitude for all angles.
- Evolution of $\langle N \rangle/Z$ over 2-3 zs (600-900 fm/c)
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- Difference in $\langle N \rangle/Z$ time dependence for different ZL may be related to differences in the initial di-nuclear configuration (different position relative to saddle and scission points).
- In the future, use of damped reactions at radioactive beam facilities?
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- Indiana University: A.B. McIntosh, S. Hudan, J. Black, D. Mercier, C.J. Metelko, R. Yanez, R.T. de Souza
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- WMU: M. Famiano

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