STUDIES OF BREAKUP MECHANISMS IN THE REACTION OF E/A = 25 MeV ^{6}Li IONS WITH ^{232}U

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Semi-exclusive studies of light charged particles in coincidence with angle-correlated fission fragments have been measured for the reaction of E/A = 25 MeV ^{6}Li ions with ^{238}U.[1] Linear momentum transfer properties were derived from the fission fragment folding angle measurement.

The data demonstrate the existence of fission following the transfer of all possible components of the ^{6}Li projectile, including inelastic scattering. Absorptive breakup involving ^{4}He - ^{2}H cluster structure is found to be the dominant reaction mechanism. Figure 1 shows the linear momentum transfer distributions as a function of angle for deuteron, triton and alpha particle ejectiles. The folding angle distributions

Figure 1. Fission fragment linear momentum transfer distribution gated on deuterons, tritons, and ^{4}He ions at several angles. Dashed lines represent the expected centroid for transfer of a ^{4}He ion (deuteron spectra),

have been transformed into a longitudinal linear momentum transfer scale, $p_\parallel/p_{beam}$, which includes only the linear momentum of the fissioning nucleus. For ejectile angles greater than 60 deg, the count-rate for complex ejectiles was too small to give meaningful statistics in this measurement. In Table I we compare the total linear momentum transfer balance, as measured in these experiments, with that of the bema in terms of a variable R, where

$$R = \frac{\langle p_\parallel \rangle_{LCP} + \langle p_\parallel \rangle_f}{p_{beam}}$$

Here $\langle p_\parallel \rangle$ is the average longitudinal linear momentum of the light ejectile and $\langle p_\parallel \rangle_f$ is the same value for the fissioning nucleus.

The linear momentum transfer properties associated with the emission of complex fragments (Fig. 1 and Table I) are generally consistent with complete momentum balance (R = 1.0) involving two-body final states, i.e. fission preceded by emission of one prompt ejectile. The fission momentum transfer distributions gated on alpha particles, shown in Fig. 1, are representative of these ejectiles. An average momentum transfer $\langle p_\parallel \rangle \approx 1/3$ p_{beam} is found, corresponding to capture of a deuteron from the ^{6}Li projectile. Correspondingly, for deuterons $\langle p_\parallel \rangle \approx 2/3$ p_{beam}. There is also evidence for a high momentum transfer shoulder in the ^{4}He data corresponding to a small contribution from single nucleon transfer. The resultant ^{5}Li* or ^{5}He* would then undergo sequential decay to yield ^{4}He + N. This interpretation is also consistent with the proton coincidence data.[1] Correspondingly, the deuteron spectra exhibit a low momentum transfer
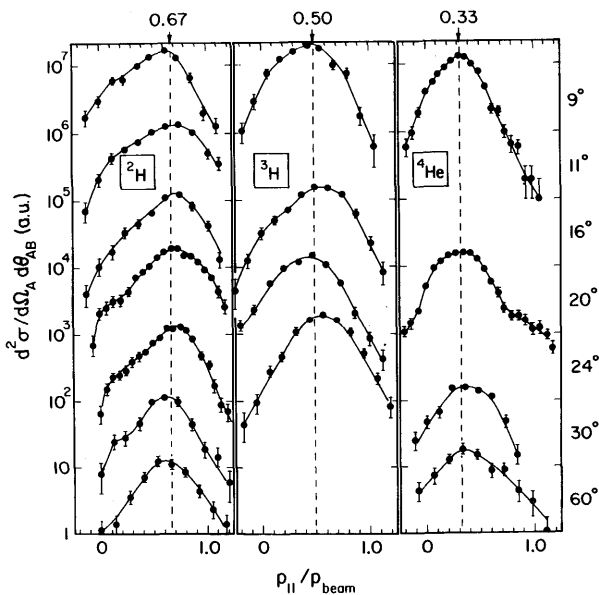
TABLE I

Θ_{LCP}	^{2}H	^{3}H	^{4}H
9°	1.0 ± .1	0.82 ± 0.15	0.95 ± 0.05
16°	1.0 ± .08	0.89 ± 0.12	1.0 ± 0.10
24°	1.01 ± .07	1.0 ± 0.1	---
30°	0.98 ± .06	0.85 ± 0.10	0.90 ± 0.10
59°	0.9 ± .06	---	---

Values of variable R, as defined in text, for several ejectiles at different angles of the light charged particle detector.

component, suggestive of inelastic breakup of ^{6}Li. From examination of the linear momentum balance for both deuterons and alpha particles, as well as the strong peaking of the d and α energy spectra near the E/A of the beam, it appears that α-d cluster structure continues to exercise a dominant influence on ^{6}Li-induced reactions at reaction energies near the Fermi energy.

Due to limited statistics the triton- and ^{3}He-gated momentum transfer distributions are more difficult to interpret. For the most part the A = 3 ejectiles are associated with $p_{\parallel}/p_{beam}$ values of ≈ 0.4-0.5. Hence, a major fraction of these events can be accounted for by an absorptive breakup process involving capture of three nucleons; i.e. ^{238}U(^{6}Li,^{3}H)^{241}Pu* and ^{238}U(^{6}Li,^{3}He)^{241}Np*. A preference for ^{3}He capture (with ^{3}H as the ejectile) is reflected in the relative ^{3}H/^{3}He yields. This appears to be inconsistent with an optimum Q-value transfer mechanism, for which equivalent yields of ^{3}H and ^{3}He

might be expected. The results suggest that isospin may also be important in absorptive breakup, since ^{238}U is a neutron-excess nucleus and ^{3}He capture serves to lower the isospin of the system.

Energy spectra for all coincidence light-charged particles at 9 degrees are peaked at the beam velocity. This fact and the previously-mentioned momentum transfer distributions are taken to be evidence for projectile fragmentation and absorptive breakup as the primary mechanism for producing these forward-angle light ions. However, while the widths of the deuteron and alpha-particle spectra correspond well with the predictions of a simple fragmentation pricture,[2] the widths of the proton, triton and ^{3}He spectra are significantly broader. For example, the intrinsic momentum width σ_0 for both d and α spectra yields identical values of $\sigma_0 \approx 80$ MeV/c, in good agreement with systematics for projectile fragmentation.[2] On the other hand, for protons the spectra yield $\sigma_0 = 120$ MeV/c and for ^{3}H and ^{3}He ejectiles, $\sigma_0 \geqslant 110$ MeV/c. A possible explanation for this observation may be that sequential decay processes also are important contributors to p, t and ^{3}He formation.

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2) R.G. Stokstad, Comments on Nucl. and Part. Phys., to be published (LBL-17455, 1986).