Unravelling the mechanisms for suppression of complete fusion in reactions of ^{7}Li

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A long-standing problem affecting the studies and uses of light weakly-bound nuclei is the observed suppression of above-barrier complete fusion (e.g. [1]) by $\sim$ 30% relative to calculations and to measurements for comparable well-bound systems. The mechanism for the suppression of complete fusion has long been thought to be due to projectile breakup prior to reaching the fusion barrier. However, recent work [2–5] has shown that the yields and characteristic timescales of breakup cannot explain the degree of fusion suppression. Therefore, an additional mechanism must be involved.

To investigate this mechanism, we performed comprehensive measurements of the energy and angles of singles and coincidence protons, deuterons, tritons and α-particles produced in above-barrier reactions of ^{7}Li + ^{209}Bi. By subtracting the double-differential cross-sections for α-particles produced in no-capture breakup from those of the inclusive prompt α-particles, we extract the double-differential cross-sections for α-particles unaccompanied by any other charged fragment. These unaccompanied α-particles are produced in the same reactions forming the polonium incomplete fusion product (whose presence is associated with complete fusion suppression).

We demonstrate that characteristics of these unaccompanied α-particles are inconsistent with the conventional picture of breakup of ^{7}Li followed by capture of a Z=1 fragment. We show that the measured distributions are in fact consistent with direct triton cluster transfer. Furthermore, coincidence measurements between projectile-like fragments and decay α-particles from the short-lived ground-state decay of ^{212}Po allows the first direct determination of their production mechanism, namely, triton transfer.

Crucially, our results [6] indicate that the suppression of complete fusion is primarily a consequence of innate clustering of weakly-bound nuclei, rather than of breakup [7].

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