Zeptosecond dynamics in breakup and consequences for suppression of complete fusion

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Above-barrier complete fusion cross sections for reactions with light, weakly bound nuclei such as ^{6,7}Li and ^{9}Be, are suppressed relative to expectations from theory and experiment [1]. This has been interpreted to be a result of the weakly bound nucleus breaking up into its cluster constituents prior to reaching the fusion barrier, reducing the probability of complete charge capture. Experiments to probe mechanisms of breakup in below barrier reactions of ^{9}Be and ^{6,7}Li with high Z targets have shown that breakup of unbound states formed following nucleon transfer dominates over direct breakup [2, 3].

Since breakup can only suppress complete fusion if it occurs prior to the nucleus reaching the fusion barrier, the location of breakup, associated with the lifetime of the resonant state, is crucial. Nuclei produced in long-lived states, such as the ground-state of ^{8}Be, cannot suppress complete fusion, since they will be carried inside the fusion barrier before breakup can occur. On the other hand, if nuclei are produced in states with lifetimes comparable to the $\sim$zeptosecond (10^{-21} s) timescale of the nuclear reaction, they may break up before reaching the fusion barrier. Recently, it has been shown that the energy and angular distributions of breakup fragments are sensitive to the location and timescale of breakup, underlining that a correct treatment of lifetime is important to correctly reproduce experimental results with theoretical modelling [4, 5].

To understand the influence of breakup on complete fusion suppression, below-barrier measurements of transfer triggered breakup, where capture is minimised can be used to predict the magnitude of above-barrier fusion suppression due to breakup alone. We will present the results of a classical dynamical trajectory model that, with below-barrier breakup probabilities as input, predicts above-barrier complete and incomplete fusion cross-sections. We will show that that these cross-sections are sensitive to the lifetime of the weakly bound nucleus produced after transfer, and that when realistically modelled, the inclusion of lifetime leads to the conclusion that breakup alone cannot account for the observed suppression of complete fusion.

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