Reduced suppression of complete fusion due to breakup after incorporating lifetime effects

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Above barrier measurements of complete fusion of light, weakly bound nuclei such as ^{9}Be in reactions with heavy targets such as ^{209}Bi indicate a suppression of complete fusion relative to single barrier penetration model calculations [1]. This suppression may be interpreted as the result of the breakup of ^{9}Be prior to the distance of closest approach, producing a smaller probability of both fragments being captured, and an increased probability of only one fragment being captured – incomplete fusion. Incomplete fusion was pioneered as a tool in spectroscopy studies by George Dracoulis [2].

In order to understand the contribution of breakup to the suppression of complete fusion, the reaction dynamics group at the Australian National University have developed coincidence measurement and reconstruction techniques to measure the breakup of light, weakly bound nuclei after interactions with a target. In below-barrier measurements of the breakup of ^{9}Be on various heavy targets ranging in mass from ^{209}Bi to ^{144}Sm, it has been found that breakup is predominantly triggered by the transfer of one or more nucleons – in the case of ^{9}Be, neutron stripping forming ^{8}Be, which subsequently breaks up into two alpha particles [3].

Below-barrier breakup probabilities extracted from these measurements, coupled with the classical trajectory model `PLATYPUS` [4] have then been used to predict fusion suppressions between 20% and 30% [3], close to empirical predictions and experimental results for ^{9}Be + ^{208}Pb. In order to reproduce the experimental signatures of breakup of light-weakly bound nuclei after interactions with lighter targets, `PLATYPUS` has been extended to include excitation of the projectile into resonant states, rather than the continuum. These resonances have a width, and therefore a lifetime. In the case of ^{8}Be, signatures of excitation into the resonant 2^{+} state has been observed experimentally. This state has a width of 1.5 MeV, and thus a lifetime of $\sim 10^{-22}$ s – on the order of the reaction timescale. Thus, the inclusion of the lifetime of the resonant states results in a fraction of the transfer that occurs on the incoming trajectory propagating into the outgoing trajectory. At above-barrier energies, this flux would no longer suppress complete fusion. Here, we will discuss the use of the extended `PLATYPUS` code in the analysis of the breakup of ^{9}Be on targets ranging in mass from ^{209}Bi to ^{144}Sm and present revised estimates of fusion suppression due to breakup in these systems.

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