TASCA 26
22nd Workshop on Recoil Separator for Superheavy Element Chemistry & Physics

Overturning the Understanding of Superheavy Element Synthesis Reaction Dynamics Through Direct Measurements of Sequential Fission

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Accurately predicting the reaction cross section for forming superheavy elements presents a significant challenge to their synthesis. The largest uncertainty remains the determination of the probability of compound nucleus formation, which is severely limited by quasifission.

In hot fusion superheavy element synthesis reactions, there is a long-observed quasifission mass yield peak near ^{208}Pb [1--5]. This was initially attributed to the doubly-magic nature of ^{208}Pb [6]. Time-dependent Hartree-Fock calculations of these reactions have also found mean yields to be located at the same mass, strengthening the conclusion that this is a result of microscopic shell effects [4].

However, an alternate explanation for this phenomenon attributes the peak at ^{208}Pb not to shell effects halting mass flow, but to a decrease in yield of binary events above ^{208}Pb due to their fission [6--8]. Known as ``sequential fission'', this process occurs when fragments heavier than ^{208}Pb formed by fast quasifission have excitation energy above their fission barrier --- producing a three-body reaction outcome. This process cannot be directly measured by an experiment designed for binary quasifission and therefore produces an anomalous peak once the fission barrier increases near ^{208}Pb. The conflict between these possible explanations represents a significant gap in our understanding of the mechanism of quasifission and its role in suppressing the formation of a compound nucleus for Z_{CN} > 110.

In this talk I present the results of a direct measurement of the three-body reaction outcomes of ^{50}Ti with ^{238}U, ^{244}Pu, ^{248}Cm, and ^{249}Cf at the Heavy Ion Accelerator Facility at the Australian National University. I will discuss the identification and reconstruction of sequential fission events into the intermediate fast quasifission outcome, which when combined with the simultaneous measurements of the binary quasifission shows no evidence of increased yield at ^{208}Pb in any system measured. The analysis indicates a smooth evolution between deep inelastic scattering and quasifission and provides significant insight into the dynamics of mass and kinetic-energy equilibration during the first few moments following capture.

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