Examining equilibration in heavy ion fusion using precision cross section measurements of the compound nucleus ^{220}Th

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Heavy-ion fusion is a complex, many-body quantum process, whereby two separate nuclei merge to form a single, compact compound nucleus. It is intrinsically dissipative, requiring the kinetic energy of the collision to be dispersed into a multitude of internal nucleonic excitations. Existing models of fusion, accounting for the coherent superposition of collective excited states [1], have been quite successful in predicting the outcome of fusion at energies near and below the fusion barrier. Crucially, however, these models do not explicitly treat the progression of the system from a fully coherent quantum state to the thermalised, compact compound nucleus. As a consequence, predictions of fusion cross sections at above barrier energies with these models may disagree with experiment by up to a factor of 2 [2].

Determining the variables which control this thermalisation is a key step in understanding the progression towards a fully energy-dissipated compound nucleus. One variable thought to be important is the amount of nuclear matter overlap at barrier radius. This matter overlap is controlled by the entrance channel charge product, Z_pZ_t. Experimental studies of the same compound nucleus formed using differing Z_pZ_t will reveal how this variable influences compound nucleus formation.

This talk will outline the experimental program designed to measure the outcomes following compound nucleus formation: evaporation residue (ER) formation and fusion-fission. Measuring the cross section of compound nucleus decay modes will then allow quantification of other collision outcomes that are otherwise indistinguishable from the fusion-fission mode, in particular, quasi-fission, which is known to suppress fusion. A presentation of the development of the method to extract high-precision ER cross sections will be included, along with benchmarking reactions and initial data from the new 8T version of the SOLITAIRE experiment [3]. Preliminary fission cross sections measured with the ANU CUBE fission spectrometer will also be presented.

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[1] M. Dasgupta *et al. Measuring barriers to fusion*, Annu. Rev. Nuc. Part. Sci. **48**, 401 (1998).

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[3] M. D. Rodríguez *et al.*, *SOLITAIRE: A new generation solenoidal fusion product separator*, Nucl. Instrum. Meth. A **614**, 119 (2010).