COMPOUND-NUCLEAR REACTION CROSS SECTIONS VIA SURROGATE REACTIONS*

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Indirect methods play an important role in the determination of nuclear reaction cross sections. Often the cross section needed for a particular application cannot be measured directly since the relevant energy region is inaccessible or the target is too short-lived. An innovative indirect approach to compound-nuclear reactions, first employed in the 1970s [1], has recently been used to obtain cross sections for neutron-induced fission for various thorium, protactinium, uranium, and plutonium targets via "Surrogate" reactions [2, 3, 4].

The "Surrogate reactions method" combines experiment with theory to obtain cross sections for compound-nuclear reactions, $a + A \rightarrow B^* \rightarrow c + C$, involving difficult-to-produce targets, A. In the Surrogate approach, B^* is produced by means of an alternative ("Surrogate") reaction, e.g. $d + D \rightarrow b + B^*$, and the desired decay channel ($B^* \rightarrow c + C$) is observed in coincidence with the outgoing particle b. The reaction cross section is then obtained by combining the calculated cross section for the formation of B^* (from $a + A$) with the measured decay probabilies for this state. While the Surrogate method is very general and can in principle be employed to determine cross sections for many types of compound-nuclear reactions on a large variety of targets, there are various issues that require further study, such as the mechanisms for producing highly-excited, unbound configurations in direct reactions (both transfer and inelastic scattering reactions), the damping of such configurations into a compound nuclear system, the population of available angular-momentum values in a compound nucleus, and their impact on the compound-nuclear decay.

This presentation will give a brief outline of the Surrogate approach and the challenges involved in carrying out a complete Surrogate treatment. The assumptions underlying the experimental work carried out so far will be detailed and calculations that test the validity of the approximations employed will be presented. Prospects for using the Surrogate method to obtain cross sections relevant to the astrophysical s process will be discussed.

References

[1] J.D. Cramer and H.C. Britt, Nucl. Sci. and Eng. **41**, 177 (1970); H.C. Britt and J.B. Wilhelmy, *ibid.* **72**, 222 (1979).

[2] W. Younes and H.C. Britt, Phys. Rev. C **67**, 024610 (2003), *ibid.* **68**, 034610 (2003).

[3] M. Petit *et al.*, Nucl. Phys. **A 735**, 345 (2004).

[4] C. Plettner *et al.*, Phys. Rev. C **71**, 051602 (2005); J. Burke *et al.*, LLNL report UCRL-TR-214631 (to be published).

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