A new hybrid surrogate ratio method for neutron-induced fission cross section measurements of short-lived actinides

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Neutron-induced fission cross sections of short-lived actinides play a role in many areas of nuclear physics and astrophysics such as nucleosynthesis, stockpile stewardship, and nuclear energy research. Different surrogate methods (absolute, ratio and hybrid) have been employed involving stable target and projectile nuclei to estimate the compound nuclear cross sections for short lived target nuclei to circumvent technical challenges presented by the fabrication of unstable radioactive targets and the production of high-flux neutron beam [1-3]. In the absolute surrogate method [1], the measured decay probability of a compound nucleus formed via a direct reaction is used to extract the cross section for a reaction with different entrance channel that proceeds through the same compound nucleus. An extension of surrogate method, surrogate ratio method [2], uses a ratio of measured decay probabilities to infer an unknown cross section relative to the known one. This is accomplished by performing the same surrogate reaction on two different targets and measuring a ratio of compound nuclear decay probabilities.

Recently, a new hybrid surrogate ratio approach [3] has been employed by us to determine ^{233}Pa(n,f) cross section in the excitation energy range of 11.5 MeV to 16. MeV for the first time. In the present hybrid approach, using a single target the compound nuclei, ^{234}Pa and ^{236}U are formed in-situ in two different direct reactions ^{232}Th(^{6}Li, α)^{234}Pa and ^{232}Th(^{6}Li, d)^{236}U respectively. By using the same target to populate two compound systems, the uncertainty due to the target thickness and beam normalization have been eliminated. The ^{234}Pa and ^{236}U compound nuclei are treated as surrogate of n+^{233}Pa→^{234}Pa and n+^{235}U→^{236}U reactions. The present measurement is unique that the two compound residues are formed with overlapping excitation energy spectrum, which has helped us to employ surrogate ratio method to extract the ^{233}Pa(n,f) cross section. We have also carried out measurement of ^{234}Pa(n,f) cross section employing ^{232}Th(^{7}Li, α)^{235}Pa and ^{232}Th(^{7}Li, t)^{236}U reactions respectively. We will present a brief review of various surrogate methods employed for compound nuclear cross-section measurements along with our recent results using the hybrid surrogate ratio approach for determination of neutron induced fission cross sections of ^{233}Pa and ^{234}Pa isotopes.

References:

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