Surrogate Ratio Method: An option without neutron

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Introduction

The elements which were either created during the big bang or during fusion reactions in stars, majority of the elements having higher atomic mass than iron are produced via neutron-induced reactions. Therefore, neutron capture cross sections of stable and unstable isotopes are important. One of the vital role of neutron induced reaction cross section is its use in the nuclear waste management programs. In a nuclear reaction of our interest, to describe the probability that a nuclear reaction will occur, we determine the cross section of the reaction. It is easy to determine the reaction cross section of a nuclear reaction involving stable nuclei [1–7]. But, for a nuclear reaction involving unstable nuclei, similarly in the absence of neutron as a projectile we can not do neutron cross section measurements, it is impossible to measure the reaction cross section directly . To overcome this problem many indirect methods were proposed to measure the cross section of the nuclear reaction involving unstable nuclei. Surrogate reaction method is one of them. Earlier, surrogate techniques were used in the simplest form, in which compound nuclear formation cross section is multiplied by the branching ratio for the decay of the compound nucleus into the desired exit channel to deduce the (n,f) cross section. On comparing with case in which (n,f) cross section had been measured directly, indicated that simple surrogate method could give estimated (n,f) cross section having accuracy of order 10-20 % for incident neutron energies above 1.0 MeV. A new approach in surrogate method named surrogate ratio method is employed which reduces the systematic uncertainties which were present in applying the simple surrogate technique [8]. Surrogate ratio method has advantage that dependence on j^{π} vanishes for excitation energy more than 8.0 MeV [9]. In surrogate ratio method, we determine the relative compound nuclear decay probabilities and the unknown neutron induced reaction cross section is then derived relative to reference reaction, that is well known. There are two ways of application of surrogate ratio method(SRM), (i) Internal SRM, (ii) External SRM, and here we are using external surrogate ratio method.

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Technique applied

In the present work we have two following desired reactions:

1) n + $^{30}P \rightarrow$ $^{31}P^{*} \rightarrow$ ^{30}Si + p

2) n + $^{29}Si \rightarrow$ $^{30}Si^{*} \rightarrow$ ^{29}Al + p

We would like to populate the desired compound nuclei followed by two surrogate reactions:

$^{7}Li + ^{28}Si \rightarrow\ ^{31}P^{*} + \alpha$

$^{7}Li + ^{27}Al \rightarrow\ ^{30}Si^{*} + \alpha$

In the present work we are studying the cross section measurement for ^{30}P(n,p) by using external surrogate ratio method with using ^{29}Si(n,p) as reference reaction. We will be measuring the proton decay probability of the desired compound nuclei (^{31}P and ^{30}Si) by measuring the protons in coincidence with α from ^{7}Li breakup.

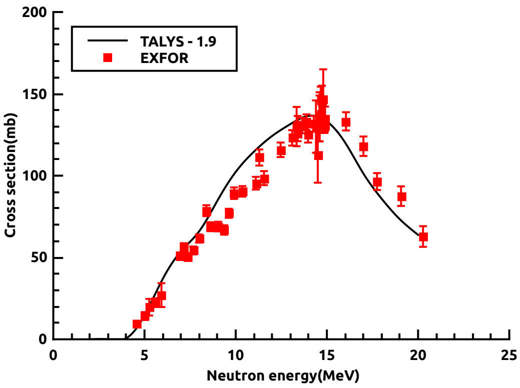

FIG. 1:
A comparison of theoretical cross section for ^{29}Si(n,p)^{29}Al using TALYS- 1.9 with EXFOR data.

Conclusion

To find cross section of nuclear reaction involving unstable nuclei, we have applied external surrogate ratio method. Indeed this method reduces the systematic uncertainties which were present in case of simple surrogate technique, where we want to measure ^{30}P(n,p) cross section, taking ^{29}Si(n,p) as reference reaction . We have calculated (n,p) cross section of our reference reaction ^{29}Si(n,p), using TALYS- 1.9 and compared it with EXFOR data, as shown in Fig. 1.
More details will be discussed during the symposium.

References

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