Re-Estimation of Cross section data for the IAEA EXFOR ID:40803 for ^{232}Th (n,γ)^{233}Th using covariance analysis technique

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Introduction

Nuclear data provides numerical values by quantifying nuclear physics interactions. These numerical nuclear data includes both experimental and evaluated having great importance in all areas of science and technology. Experimentally generated nuclear data are not available at all energies to cover various nuclear applications. So the experimental data have to be evaluated. The nuclear data evaluation includes re-normalization of available experimental data, science based models, systematics and statistical or mathematical tools. The uncertainties associated with the nuclear data is also important in the evaluation process, they contributes to both safety and economy in nuclear applications. So the correlation (covariance) among the data points has to be considered to avoid the over estimation or under estimation of the uncertainties, in the quantity of interest[1].

Keeping the above facts in view cross section data of ^{232}Th (n,γ)^{233}Th reaction reported by V A Tolstikov et al [2] also available in IAEA EXFOR ID: 40803 is re-estimated. Methods of re-estimation and results are discussed following sections.

Methods of Re-estimation

In the work reported by V A Tolstikov et al [2] the cross section data of ^{232}Th (n,γ)^{233}Th having neutron energy ranges from 5-200 KeV were measured relative to the cross section of the reaction ^{10}B(n,α). The neutron source for this reaction is ^{7}Li(p,n) reaction. In the present work the above reported data was re-estimated with the recently reported data of ^{10}B(n,α) as the monitor[3].

$$\sigma_{Thnew} = \frac{\sigma_{Thold}}{\sigma_{Bold}}\sigma_{Bnew} \quad (1)$$

σ_{Thnew} is the Re-estimated cross section of ^{232}Th (n,γ)^{233}Th σ_{Thold} is the Cross section of ^{232}Th (n,γ)^{233}Th reported[2] σ_{Bold} is the Cross section data of ^{10}B(n,α) reaction reported in 1967 [4] σ_{Bnew} is the New recommended cross section data of ^{10}B(n,α) reaction[3]

Due to the unavailability of factors affecting cross section such as irradiation time, efficiency, counting statistics etc, only the uncertainties in energy is considered here. This is propagated to the final uncertainty in cross section. Energy spectra of ejected neutrons corresponding to each energy reported in the paper were calculated using EPEN code [5]. The uncertainties in re-estimated cross section were generated.By taking correlation for each incident energy,correlation matrix between uncertainties were generated.Using this correlation matrix covariance of uncertainties were calculated as follows,

$$Covariance\ matrix = ZCZ^T \quad (2)$$

Where, Z is the Diagonal matrix of uncertainties in re-estimated cross section of ^{232}Th (n,γ)^{233}Th, Z^T is the Transpose of Z, C is the Correlation matrix of energy

Re-estimated cross section data of ^{232}Th (n,γ)^{233}Th reaction is fitted using generalized least square method, the function used to fit the data is,

$$f(x) = \frac{a}{x^3} + \frac{b}{x^2} + \frac{c}{x} + d \quad (3)$$

where a, b, c, d are the parameters. Uncertainties in the fitted data were directly generated using the

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equation, $Cov(\sigma) = AV_PA^T$, where V_P4 is the covariance matrix of fitted data. Diagonal elements of $Cov(\sigma)$ gives the variance and $Uncertainties = \sqrt{variance}$

RESULTS AND DISCUSSION

The reported, re-estimated and fitted cross section data of ^{232}Th (n,γ)^{233}Th reaction along with uncertainties is given in Figure 1. The uncertainties obtained for re-estimated data are very high, but the uncertainties for evaluated data are reduced by almost an order, which are tolerable. This was possible because of covariance analysis. Covariance matrix of fitted line is given in Figure 2.

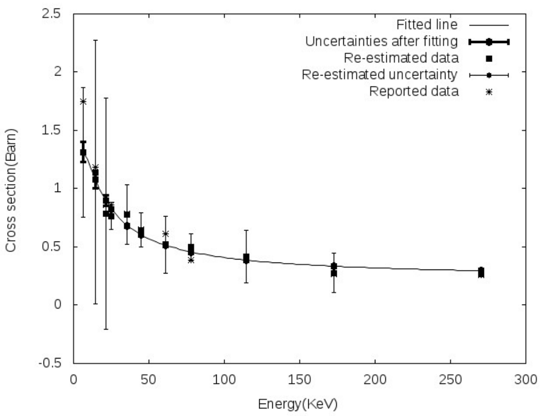

Figure 1: *Plot of reported re-estimated and fitted data along with the uncertainties*

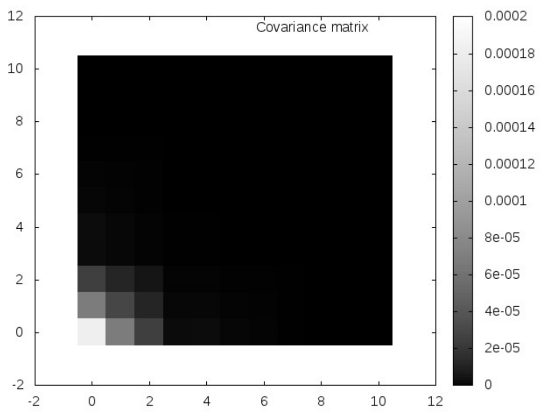

Figure 2: *Covariance matrix of fitted line*

ACKNOWLEDGMENTS

REFERENCES

[1] B. S Shivashankar, PhD thesis, Department of Statistics, Manipal University (2016)

[2] V. A.Tolstikov et al , Journal of Nuclear Energy Parts A/B,**18**,599 (1964)

[3] G. M. Hale and P. G. Young, ENDF/B-VII.1 (2011)

[4] S. A Cox and F. R Pontet, Journal of Nuclear Energy,**21**,271 (1967)

[5] URL:epen.nhergmzu.com