Re-Estimation of Cros section data for the IAEA EXFOR ID:40803 for ^{238}U(n,γ)^{239}U using covariance analysis technique

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INTRODUCTION

Nuclear Data requires renormalization of the older data to new, updated monitor data sets. The realistic estimation of uncertainties is important in any measurements. Evaluation of uncertainties in the nuclear data, thus, has paramount importance in application of nuclear data. Particularly, as the data is, being most commonly used in nuclear power plants and radiation therapy. Recent interest has been focused on producing covariance data to a far greater extent than ever before. Today, covariance data are more widely and extensively utilized than ever before in the fields of neutron dosimetry, advanced fission reactor design studies, nuclear criticality safety assessments, national security applications etc. Most of the experimental nuclear data is incomplete since it doesnt include uncertainties.

Keeping the above facts in view cross section data of reaction reported by V.A Tolstikov et al in 1964[1] also available in EXFOR ID:40803 is re-estimated and uncertainties are constructed.

MATERIALS AND METHODS

Cross section evaluation of ^{238}U (n,γ)^{239}U ,a compound type reaction is re-estimated by monitor source ^{10}B(n,α) in the energy range 1-200KeV using Li(p,n) as neutron source is reported in 1964[1]. Using new recommended data of ^{10}B(n,α), the reported in 2011[2] data was re-estimated as follows.

$$\sigma_{Unew} = \frac{\sigma_{Uold}}{\sigma_{Bold}} \sigma_{Bnew} \qquad (1)$$

where

- σ_{Unew} :Re-estimated cross section
- σ_{Uold} : Reported ^{238}U (n,γ)^{239}U cross section
- σ_{Bold} : Monitor cross section ^{10}B(n,α) reported in 1967[3]
- σ_{Bnew} : Newly recommended monitor data ^{10}B(n,α) in 2011[2]

The energy distribution of ejected neutron were calculated using EPEN code[4] for the reported target thickness. The spectrum averaged energy and the energy spread of neutron are deduced from the generated spectrum, where the asymmetric neutron spread is also accounted for determining the neutron energy and uncertainty in energy. The deviation to positive and negative side are evaluated separately with resampling the Gaussian into skewed Gaussian, where the centroid is fixed at the average energy. The factors affecting uncertainty in the cross section such as counting time, Irradiation time and the counting statistics are not reported in EXFOR ID: 40803. Hence the uncertainty evaluation was confined to energy spread only. The generated uncertainty is propagated to the final cross section.

Correlation matrix between uncertainties are constructed by taking correlation in the neutron spectra for each incident energy. Using this correlation matrix, covariance of uncertainties are generated as,

$$Covariance, Z = ASA^{-1} \qquad (2)$$

Where, S is the correlation matrix and A is the error matrix. By means of Generalized Least Square Fitting, a smooth function

$$f(x) = \frac{a_1}{x^3} + \frac{a_2}{x^2} + \frac{a_3}{x} + a_0 \qquad (3)$$

where a_0, a_1, a_2, a_3 are parameter values that approximately fits the re-estimated data. The uncertainties associated with the fitted function can be found by using, $Cov(\sigma) = ACov(\beta)A^T$ Where, $Cov(\beta)$ is the Covariance of Parameter matrix and A is the Design matrix. The diagonal elements of $Cov(\sigma)$ gives the variance, and uncertainties are the square root of variance.

Results and Discussion

The reported Uranium, re-estimated ^{238}U (n,γ)^{239}U data with newly recommended ^{10}B(n,α)[2] along with generated uncertainties and fitted data using χ^2 minimization are shown in Figure 1. The uncertainty obtained for re-estimated data are high. By using covariance analysis the uncertainty in re-estimated data is reduced to tolerable limit. Covariance matrix for the fitted line is given in Figure 2.

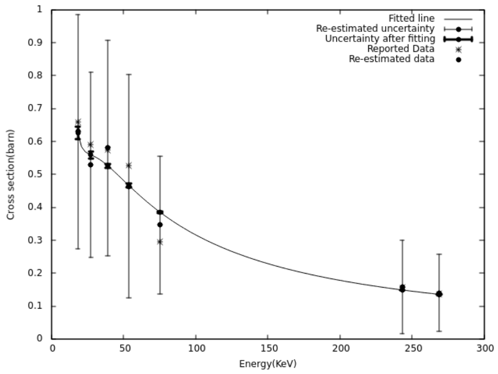

Figure 1: *Plot of reported re-estimated and fitted data along with the uncertainties*

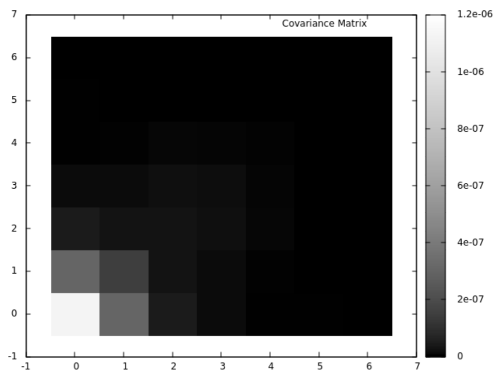

Figure 2: *Covariance matrix of fitted line*

References

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