Covariance Data for ^{232}Th in the Resolved Resonance Region

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This paper reports on the generation and testing of the covariance matrix associated with the resonance parameter evaluation for ^{232}Th up to 4 keV. [1]

Over the years, efforts have been made to improve the quality of basic nuclear data. Thermal reactor designs and applications have been the driving force for new data evaluations in the low-energy range. Data evaluations in the high-energy region have been accomplished primarily in support of shielding applications and fast reactor design. Error estimation for calculated nuclear systems quantities requires nuclear data uncertainty information, which should be available from the basic nuclear data libraries such as the U.S. Evaluated Nuclear Data File (ENDF/B).

Although the accuracy of the nuclear data (such as neutron interaction cross sections) has significantly improved, little information exists on nuclear data uncertainties, and even less exists on nuclear data covariances. Hence, until very recently, little uncertainty or covariance information had been included in ENDF/B. Efforts are now under way to correct these deficiencies.

In the resonance region, reconstruction of the pointwise cross section is frequently carried out by using a cross-section formalism derived from the R-matrix theory that uses evaluated resonance parameters. The uncertainties in the cross section are due to the uncertainties in the resonance parameters. For reactor applications, group cross sections are produced by weighting the pointwise cross sections with a neutron flux spectrum. Consequently, the uncertainty in the group cross sections is also dependent on the uncertainty in the resonance parameters. Resonance parameters can be obtained by fitting the experimental data using generalized least-squares technique in conjunction with R-matrix theory. Such an approach is used in the computer code SAMMY [2] together with Bayes' method (generalized least squares) for sequential analyses of the available experimental data.

Evaluation of experimental data (transmission or total cross section, capture, or fission cross section) incorporates uncertainties in these data. These uncertainties come from a variety of sources such as normalization, background, neutron time-of-flight, sample thickness, etc. These uncertainties are included in the evaluation process, in order to properly determine the long-range correlation in the resonance-parameter covariance matrix.

Preliminary results of group-averaged cross sections and uncertainties generated using the resonance covariance of ^{232}Th are shown in Table 1 for average capture cross sections calculated for an energy-constant neutron spectrum using the 44-group structure of the SCALE system. The correlation matrix of the capture cross section is shown in Fig. 1.

In the full paper, the method used to determine the resonance-parameter covariance matrix for ^{232}Th will be described. The procedure to process covariance data using the processing code PUFF-IV [3] will also be described. The assessment of the uncertainty in the multiplication factor (k_{eff}) due to the uncertainty in the experimental cross sections is accomplished using the computer code TSUNAMI. [4]

Table 1. Average capture cross section and uncertainty for ^{232}Th calculated with SAMMY

I	E_{min}	E_{max}	σ	δσ
1	0.00001	0.003	40.7465	1.32952
2	0.003	0.0075	16.6662	0.543446
3	0.0075	0.01	12.6052	0.410773
4	0.01	0.0253	9.04371	0.294307
5	0.0253	0.03	7.01618	0.227933
6	0.03	0.04	6.22523	0.202003
7	0.04	0.05	5.45892	0.176858
8	0.05	0.07	4.70415	0.152059
9	0.07	0.1	3.90884	0.125892
10	0.1	0.15	3.16911	0.101518
11	0.15	0.2	2.61193	8.316151E-02
12	0.2	0.225	2.32568	7.374910E-02
13	0.225	0.25	2.17571	6.882891E-02
14	0.25	0.275	2.04701	6.461704E-02
15	0.275	0.325	1.88556	5.935308E-02
16	0.325	0.35	1.74822	5.489914E-02
17	0.35	0.375	1.66923	5.235072E-02
18	0.375	0.4	1.59774	5.005474E-02
19	0.4	0.625	1.33163	4.162456E-02
20	0.625	1.0	0.946675	3.000571E-02
21	1.0	1.77	0.606446	2.080525E-02
22	1.77	3.0	0.357411	1.485115E-02
23	3.0	4.75	0.213502	1.106095E-02
24	4.75	6.0	0.149953	8.793070E-03
25	6.0	8.1	0.118056	8.702677E-03
26	8.1	10.0	0.165135	0.111094
27	10.0	30.0	46.6725	0.875735
28	30.0	100.0	16.1891	0.193321
29	100.0	550.0	8.26973	4.308997E-02
30	550.0	3000.0	3.85223	7.612263E-02
31	3000.0	4000.0	1.15663	3.015903E-02

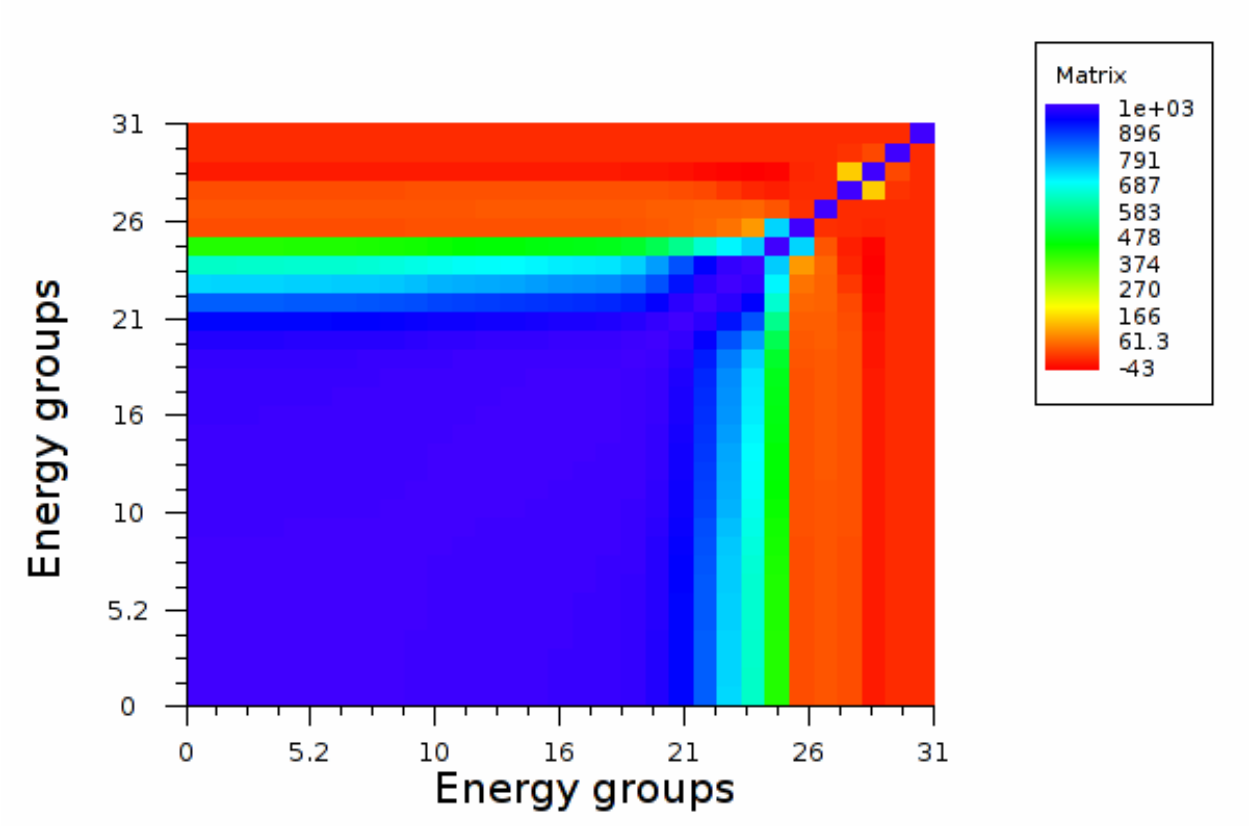

Fig. 1. Correlation matrix for the capture cross-section data calculated with the computer code PUFF-IV.[3]

References

[1] H. Derrien et al., "New Evaluation of ^{232}Th Resonance Parameters in the Energy Range 0 to 4 keV," Paper to presented at this conference.

[2] N. M. Larson, *Updated Users' Guide for SAMMY: Multilevel R-Matrix Fits to Neutron Data Using Bayes' Equations*, ORNL/TM-9179/R6 (July 2003).

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[4] B. T. Rearden, C. M. Hopper, K. R. Elam, S. Goluoglu, and C. V. Parks, "Applications of the TSUNAMI Sensitivity and Uncertainty Analysis Methodology," pp. 61–66 in *Proceedings of the 7th International Conference on Nuclear Criticality Safety (ICNC2003)*, October 20–24, 2003, Tokai-Mura, Japan (2003).