A Preliminary Study on an Uncertainty of Generated Self-shielded Total Cross Sections in an Unresolved Resonance Region

Jong Woon Kim*, Sang Ji Kim, Choong-Sup Gil, and Young-Ouk Lee
Korea Atomic Energy Research Institute, 1045 Daedeokdaero, Yuseong-gu, Daejeon, Korea, 305-353
Corresponding author: jwkim@kaeri.re.kr

1. Introduction

In previous research [1], we presented a method to generate self-shielded multi-group cross sections in URR for easy numerical integration.

Main idea was that, in URR, we generated statistical resonances on given energy points by random sampling based on the probability table and combine these statistical resonances with smooth cross sections.

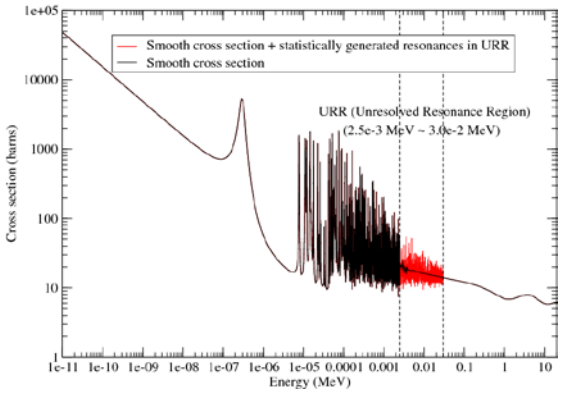

Fig. 1. Two sets of pointwise cross sections with/without statistically generated resonances in URR.

Figure 1 shows two sets of pointwise cross sections; smooth cross section (black color) and combined cross section (smooth + statistical resonance, red color).

The generated statistical resonance cross sections in URR give different values whenever our program runs since these are generated by random sampling based on the probability table in UNR block of ACE file.

The self-shielded multi-group cross sections in URR also give different values since these are determined by the numerical integration of pointwise cross sections that include statistical resonances.

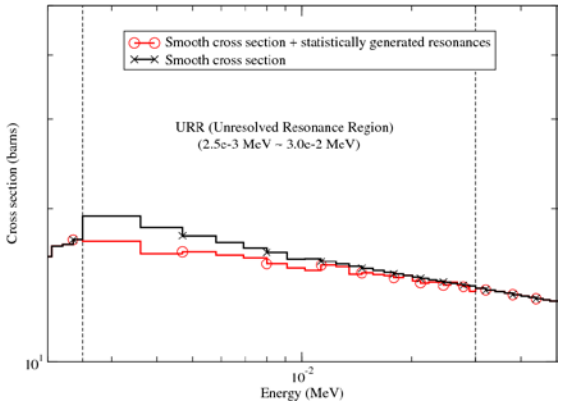

Fig. 2. Typical self-shielded multi-group total cross sections of ^{239}Pu.

In Fig. 2, we compared self-shielded multi-group total cross sections by using one typical statistical resonance set in URR.

In this paper, we present an uncertainty of generated self-shielded multi-group total cross sections in URR.

2. Method and results

2.1 Method

The schematic view of our method is shown in Fig. 3. We run our program 100 times and get 100 sets of self-shielded multi-group total cross sections. These cross sections have slightly different values in URR.

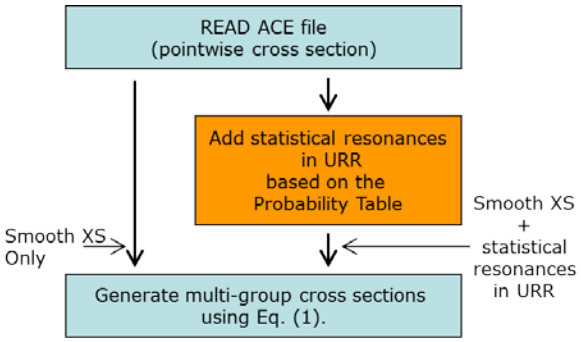

Fig. 3. Diagram of method.

We calculate the average and standard deviation for each energy group and compared with smooth cross section only case.

In previous paper [1], 1/E was missed in the equation for numerical integration and the corrected one is

$$\bar{\sigma}_{xg}^{i} = \int_{\Delta E_g} \sigma_x^i(E) \frac{1}{\Sigma_t(E)} \frac{1}{E} dE \Big/ \int_{\Delta E_g} \frac{1}{\Sigma_t(E)} \frac{1}{E} dE, \quad (1)$$

where

$\bar{\sigma}_{xg}^{i}$: effective cross section of group g for reaction type x of isotope i,

σ_x^i : microscopic cross section for reaction type x of isotope i,

$\Sigma_t(E)$: total macroscopic cross sectons of mixture.

2.2 Results

The average and standard deviation of generated 100 self-shielded multi-group total cross sections are calculated for 94-Pu-239, 94-Pu-241, 92-U-235, and 92-U-238 and compared with smooth only case.

The used parameters are listed in Table I. For 94-Pu-239, 92-U-235, and 92-U-238, 10,000 energy points in URR are used. However, For 94-Pu-241, 100,000 energy points in URR is used because the range of URR is much wider than other nuclide.

The range of URR for each nuclide is marked with bold in group structure data section in Table I.

Table I: Parameters for numerical test

Information of nuclide		
Temperature (K)		293.6
Library		ENDF/B-VII.0
Atomic density (atoms/b-cm)		1.0
URR data		
Number of energy points in URR for generating statistical resonances	94-Pu-239 92-U-235 92-U-238	10,000
	94-Pu-241	100,000
Group structure data		
Energy group range (MeV) / Number of energy group	94-Pu-239	1.0e-3 ~ 2.5e-3 / 10 **2.5e-3 ~ 3.0e-2 / 25** 3.0e-2 ~ 5.0e-2 / 10
	94-Pu-241	1.0e-4 ~ 3.0e-4 / 10 **3.0e-4 ~ 1.0e-3 / 25** **1.0e-3 ~ 1.0e-2 / 25** **1.0e-2 ~ 4.02e-2 / 25** 4.02e-2 ~ 1.0e-1 / 10
	92-U-235	1.0e-3 ~ 2.25e-3 / 10 **2.25e-3 ~ 2.45e-2 / 25** 2.45e-2 ~ 5.0e-2 / 10
	92-U-238	1.0e-3 ~ 2.0e-2 / 10 **2.0e-2 ~ 1.490287e-1 / 25** 1.490287e-1 ~ 5.0e-1 / 10

Uncertainty only exists in URR (between two dashed lines) due to the random sampled statistical resonances. Average and one sigma in URR are shown in Figs. 4-7 for each nuclide.

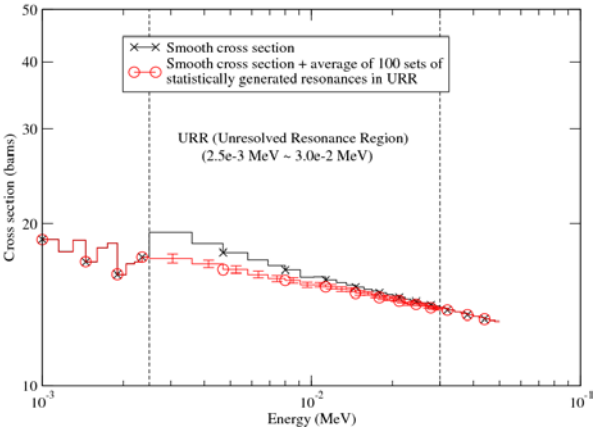

Fig. 4. Comparisons of generated self-shielded multi-group total cross sections of ^{239}Pu (error bar is 1σ).

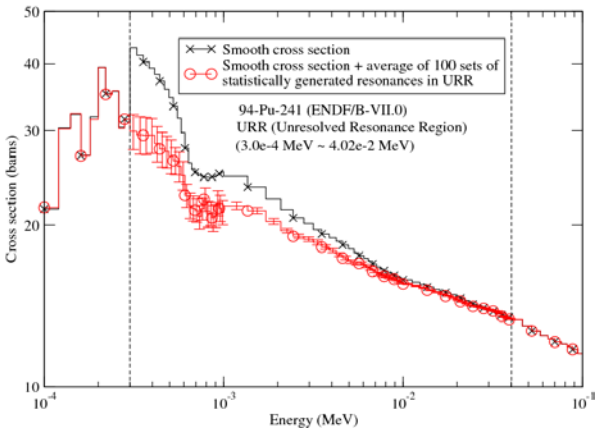

Fig. 5. Comparisons of generated self-shielded multi-group total cross sections of ^{241}Pu (error bar is 1σ).

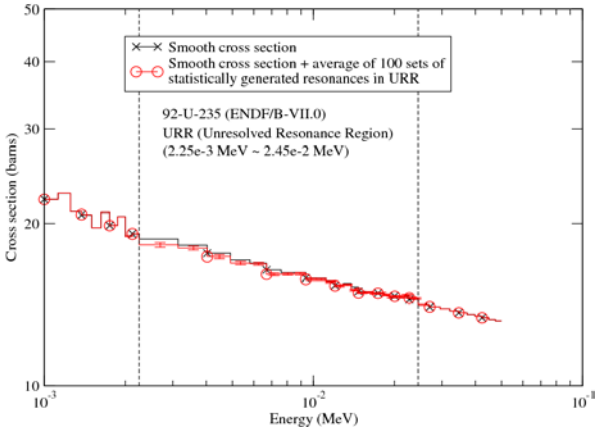

Fig. 6. Comparisons of generated self-shielded multi-group total cross sections of ^{235}U (error bar is 1σ).

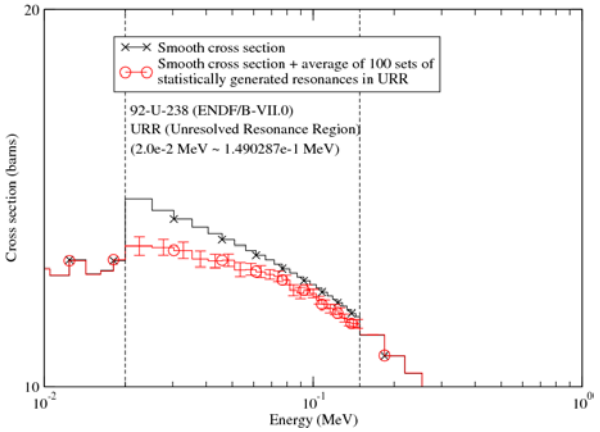

Fig. 7. Comparisons of generated self-shielded multi-group total cross sections of ^{238}U (error bar is 1σ).

Even though we consider one sigma uncertainty, the tendency that self-shielded cross section gives less value than that of smooth only case (infinite diluted) can be confirmed. The unresolved resonance total cross sections with infinite diluted and a few background cross sections, downloaded from LANL T2 site, are showed in Fig. 8-11.

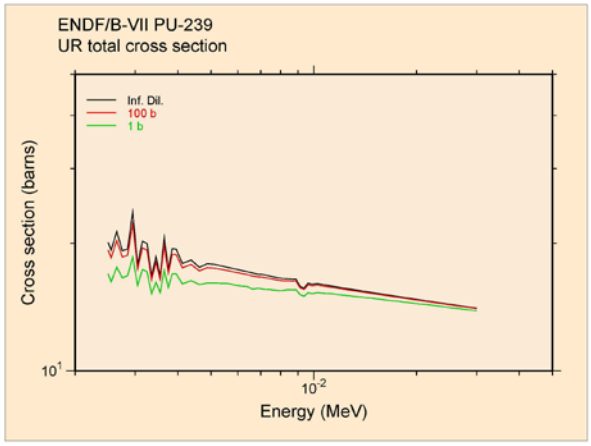

Fig. 8. Unresolved total cross section of ^{239}Pu from LANL T2 site [2].

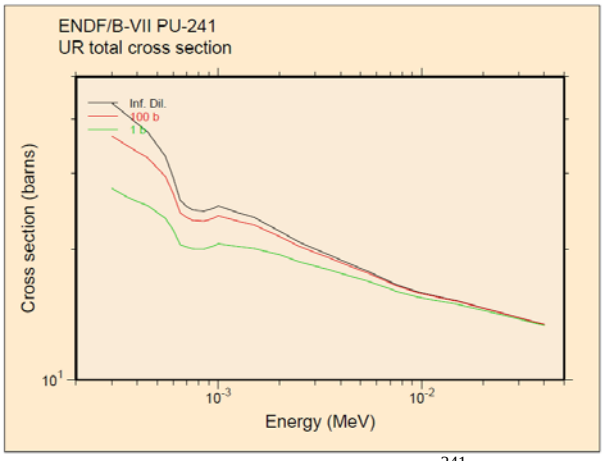

Fig. 9. Unresolved total cross section of ^{241}Pu from LANL T2 site [3].

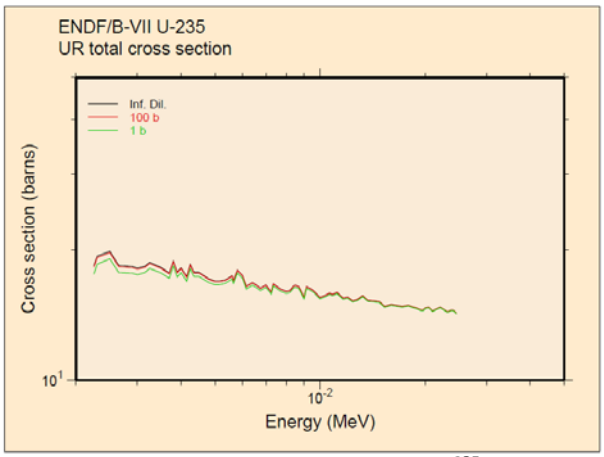

Fig. 10. Unresolved total cross section of ^{235}U from LANL T2 site [4].

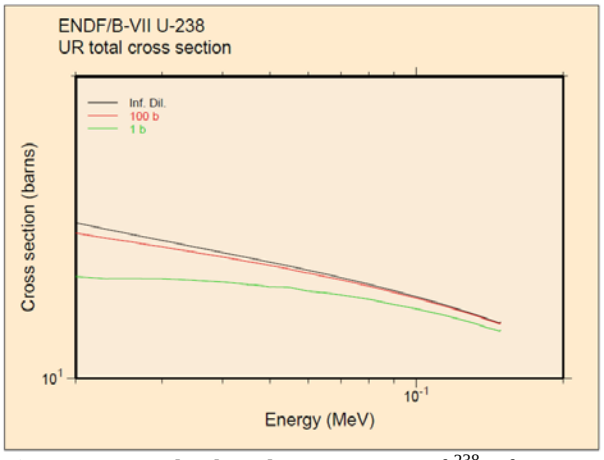

Fig. 11. Unresolved total cross section of ^{238}U from LANL T2 site [5].

3. Conclusions

We present how much randomly sampled statistical resonances in URR affect the self-shielded multi-group cross sections. One hundred sets of self-shielded multi-group cross sections are used to get average and standard deviation of each group belong to the URR.

Currently, coding our program is in progress, and we will check to see how any impact on the final results.

Acknowledgement

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REFERENCES

[1] Jong Woon Kim, Sang Ji Kim, Choong-Sup Gil, and Young-Ouk Lee, “A Preliminary Study on a Method for Generating Self-shielded Multi-group Cross Sections in an Unresolved Resonance Region,” *Transactions of the Korean Nuclear Society Autumn Meeting*, Pyeongchang, Korea, October 2014.
[2] http://t2.lanl.gov/nis/data/endf/endfvii-n-pdf/pu/239.pdf
[3] http://t2.lanl.gov/nis/data/endf/endfvii-n-pdf/pu/241.pdf
[4] http://t2.lanl.gov/nis/data/endf/endfvii-n-pdf/u/235.pdf
[5] http://t2.lanl.gov/nis/data/endf/endfvii-n-pdf/u/238.pdf