Sensitivity and Uncertainty Evaluation on the k_{eff} of GODIVA by an ERRORJ/SUSD3D Code System with JENDL-3.3

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1. Introduction

For an accurate estimation of the nuclear data uncertainties in the nuclear integral parameters such as the k_{eff}, reactivity coefficients, isotopic inventories in the spent fuel, etc., the covariance data should be included in the evaluated nuclear data files. However, the covariance data is only available for limited numbers of nuclides in the present evaluated nuclear data files. Recently, considerable efforts have been made in the generation and application of the covariance data.

In this study, the covariance data processing and the nuclear data sensitivity and uncertainty (S/U) analysis of the k_{eff} have been carried out according to the procedures shown in Fig. 1. The uncertainties of the k_{eff} due to the U-235 and U-238 cross sections of JENDL-3.3 have been estimated for the 1-D fast benchmark GODIVA.

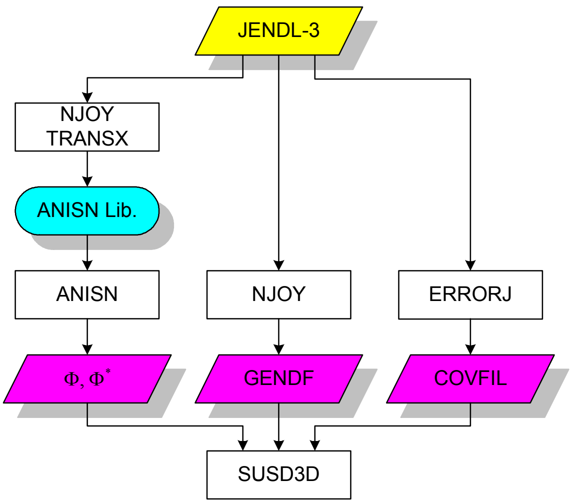

Figure 1. Code system for the sensitivity and uncertainty analysis.

2. Covariance Data Processing

The ERRORJ code [1] has been used to produce the 30-group covariance matrices based on the JENDL-3.3. Figures 2 and 3 show the relative standard deviations (%) for the reaction cross sections of U-235 and U-238, respectively. For U-235, the inelastic scattering cross section contains the largest uncertainty when compared to other reaction cross sections. Especially, the uncertainties of the elastic scattering and capture cross sections are significant in the fast energy region. For U-238, the capture cross section contains the largest uncertainty. The elastic and inelastic scattering cross sections have large uncertainties of more than ~10% in the fast energy region.

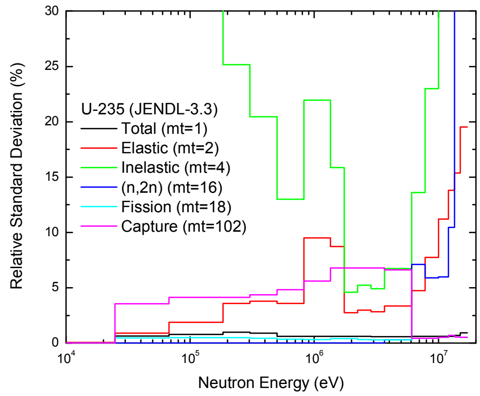

Figure 2. Relative standard deviation (%) in reaction cross sections of U-235.

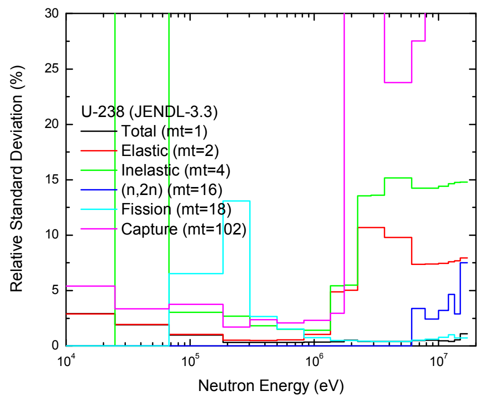

Figure 3. Relative standard deviation (%) in reaction cross sections of U-238.

3. S/U Analysis of Criticality

The nuclear data S/U analysis of k_{eff} has been performed for the 1-D spherical GODIVA benchmark problem, which is composed of 93% enriched U-235, U-238, and U-234. The JENDL-3.3 was processed by the NJOY99.90 [2] and ERRORJ codes to generate the group-wise ENDF (GENDF) files and 30-group covariance matrices, respectively. The forward and adjoint fluxes were obtained from the ANISN [3] calculations (P_3-S_4 approximations). The ANISN-format, problem-dependent, macro-scopic cross section libraries were prepared by the NJOY99.90/TRANSX [4] codes. Finally, the SUSD3D [5] code was utilized for the S/U analysis.

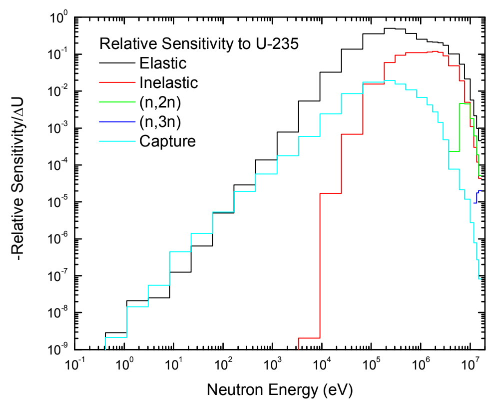

Figure 4. Relative sensitivity (negative) to U-235 cross sections.

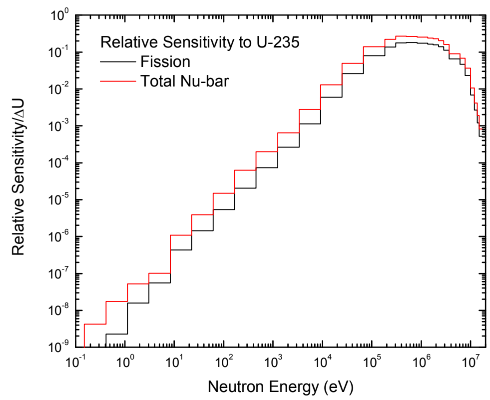

Figure 5. Relative sensitivity (positive) to U-235 cross sections.

Figures 4 and 5 show the relative sensitivities to the U-235 cross sections for GODIVA. The elastic and inelastic scattering cross sections are highly and negatively sensitive in the fast energy region, while the fission and total nu-bar cross sections are positively sensitive. As shown in Fig. 6, the U-235 cross sections were more sensitive to the k_{eff} calculation for GODIVA than U-238. Especially, the elastic scattering cross section of U-235 can provide the largest uncertainties to the k_{eff} calculation. As a result, the uncertainty of the k_{eff} due to the U-235 and U-238 cross sections of JENDL-3.3 was evaluated to be ~1.4% for GODIVA (calculated k_{eff} = 1.02516).

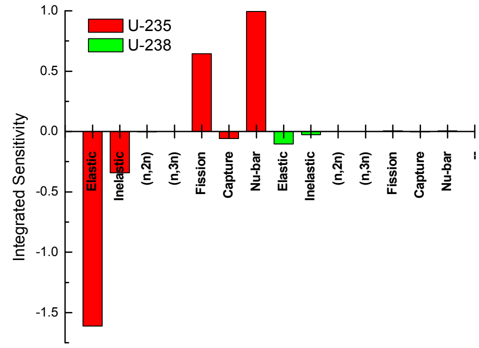

Figure 6. Integrated sensitivity to U-235 and U-238 cross sections.

In order to validate the procedures established in this paper, the uncertainty evaluations of the k_{eff} are under way for other benchmark problems such as BIGTEN, JEZEBEL, etc. It will also provide the reliability of the covariance data in the JENDL-3.3.

ACKNOWLEDGEMENT

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