

Multigroup Cross Section Generation Activities at ANL

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Outline

- ENDF/B-VII.1 Libraries for MC²-3
- Development of a Generalized Cross Section Library



Multigroup Cross Section Generation at ANL

- MC²-3 multigroup cross section generation code for fast reactor analysis
 - Use <u>ETOE-2 and NJOY</u> to generate the MC² libraries
 - Resolved resonance self-shielding using pointwise cross sections, unresolved resonance self-shielding using analytic J-function, based on analytic Doppler broadening
 - Use high-order anisotropic scattering cross sources (LS and CMS) and incident energydependent fission spectra
 - 0D or 1D transport calculations with ultrafine (2082) or hyperfine (~400,000) groups
 - Recently, we developed a rigorous resonance self-shielding approach for multidimensional geometry (M&C 2013)
 - Released to RSICC in 2012
- MC²-3 libraries
 - The MC² library with ENDF/B-VII.0 data were generated and tested using ~80 homogeneous and 1D heterogeneous problems with various combination of compositions and performed V&V with ~30 experiments and experiment-based benchmark problems
 - Recently, we processed the MC² libraries with ENDF/B-VII.1 data which are under testing using the benchmark problems
 - ETOE-2 and NJOY 2012



Benchmark Problems for V&V

LANL experiments, ZPR-6, ZPPR-15, ZPPR-21, Monju, BFS, and ABTR



Initial Verification Tests (ENDF/B-VII.0 Library)

 Comparison of MC²-3 eigenvalues with Monte Carlo (MCNP5 or VIM) solutions (1σ < 30 pcm)



V&V(ENDF/B-VII.0 Library)

 Comparison of eigenvalues from MC²-3 + deterministic codes (TWODANT or DIF3D/VARIANT) with MCNP5 solutions



V&V(ENDF/B-VII.1 Library)

- Comparison of eigenvalues between MCNP5 solutions with ENDF/B-VII.0 and ENDF/B-VII.1
 - $\Delta k = [k (MCNP w/ E7.1) k (MCNP w/ E7.0)] * 10^{5} [pcm]$



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Cr



V&V(ENDF/B-VII.1 Library)

 Comparison of eigenvalues from MC²-3 + deterministic codes (TWODANT or DIF3D/VARIANT) with MCNP5 solutions





Comparison with Measurements

ZPPR-21 (Phase A to F) and ZPPR-15 (Loading 15, 16, and 20)
1σ = 230-260 pcm
1σ = 180 pcm



Development of New Cross Section Library

- Objective
 - Overcome the limitations of multi-group cross section libraries which are currently used for the deterministic neutron transport methods
 - Develop a generalized cross section library applicable to various reactor types including LWR, VHTR, and SFR
 - Enable PROTEUS (<u>unstructured mesh</u>, discrete ordinate, neutron transport code) to simulate the complex-geometry & composition reactor such as the ATR



Cross Section Library

- Base ultrafine group cross section library (2158 groups) generated from NJOY and MC²-3
- Resonance cross sections
 - Resonance integral tables as a function of background and temperature
 - Resonance treatment of absorption, nufission, and <u>scattering</u> cross sections
 - Use of the iterative method to determine the isotopic escape cross section from the whole-core fixed source problem

$$\sigma_{e,r}^{g} = \frac{\sum_{j} \sum_{k \neq r} P_{ji}^{g} \Sigma_{t,k,j} V_{j}}{\sum_{j} P_{ji}^{g} N_{r,j} V_{j}} - \frac{1}{N_{r,i}} \sum_{k \neq r} \Sigma_{t,k,i}^{g}$$

 The UFG library is condensed to the broad group library (< 400 groups) using the group optimization algorithm with variable compositions from the reactor of interest



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Summary

- The MC²-3 libraries for ENDF/B-VII.1 data have been processed and are being verified and validated
- The generalized cross section libraries for application to various reactor types have been developed and are being tested for heterogeneous configurations