Implicit Resonance Self-Shielding Effect of Multi-Group Covariance in RXSP code

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Introduction

- RXSP is a nuclear cross section processing code being originally developed by REAL group from Department of Engineering Physics at Tsinghua University in China, which is mainly intended to reactor analysis. The current version is being developed jointly by UNIST and Tsinghua University.
- ERRORC module has been developed in RXSP to process covariance matrix data stored in MF31, MF32, MF33, MF35.

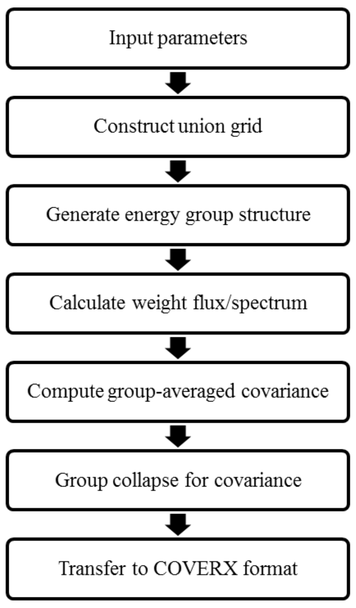

Fig. 1. General procedure of ERRORC module of RXSP code.

Methodology

- Covariance for Cross Sections

$$\mathrm{cov}\left(x_I, y_J\right) = \sum_{n(LB=0)} \mathrm{cov}\left(x, y\right)_n + \sum_{n(LB=1\sim6)} x_I x_J r\,\mathrm{cov}\left(x, y\right)_n$$

- Covariance from Resonance Parameters

$$\mathrm{cov}\left(\sigma_I, \sigma_J\right) = \sum_{i,j}\left(\frac{\partial \sigma_I}{\partial p_i}\right)\left(\frac{\partial \sigma_J}{\partial p_j}\right)\mathrm{cov}\left(p_i, p_j\right)$$

$$\mathrm{cov}\left(\sigma_m, \sigma_n\right) = \sum_{i,j} S_i^m S_j^n\,\mathrm{cov}\left(p_i, p_j\right)$$

$$S_i^m = d\sigma_m / dp_i \quad \Longrightarrow \quad S_i^m = \frac{\sigma_m\left(1.01\times p_i\right) - \sigma_m\left(0.99\times p_i\right)}{1.01\times p_i - 0.99\times p_i}$$

$$\sigma_m = \sum_{i\in m}\sigma_i\phi_i \Big/ \sum_{i\in m}\phi_i \quad \Longrightarrow \quad \phi_i = \frac{W_i}{\sigma_{t,i} + \sigma_0}$$ Bondarenko Narrow Resonance Method

- Implicit Self-shielding Effect

Flux Calculator Method borrowed from GROUPR/NJOY

$$\left[\sigma_0 + \sigma_t(E)\right]\phi_f(E) = (1-\beta)C(E)\sigma_0 + \int_E^{E/\alpha_m}\frac{\beta\sigma_e}{(1-\alpha_m)E'}\phi_f(E')dE' + \int_E^{E/\alpha_f}\frac{\sigma_{sf}(E')}{(1-\alpha_f)E'}\phi_f(E')dE' \quad \Longleftarrow \quad \phi_i = \frac{W_i}{\sigma_{t,i}+\sigma_0}$$

$$\beta = V_f\sigma_e / V_m\sigma_m$$

Numerical Verification

- Data Sources
  - ✓^{235}U from ENDF/B-VII.1
  - ✓Resonance parameters from JENDL4.0
- Tools
  - ✓ ERRORC/RXSP
  - ✓ ERRORR/NJOY(as reference)
- Options
  - ✓IWT=6
  - ✓weighting flux:thermal-1/E-fission and fusion spectrum

- Verification Results
  - ✓Covariance of cross sections
  - ✓Covariance of fission spectrum
  - ✓Covariance of nu-bar

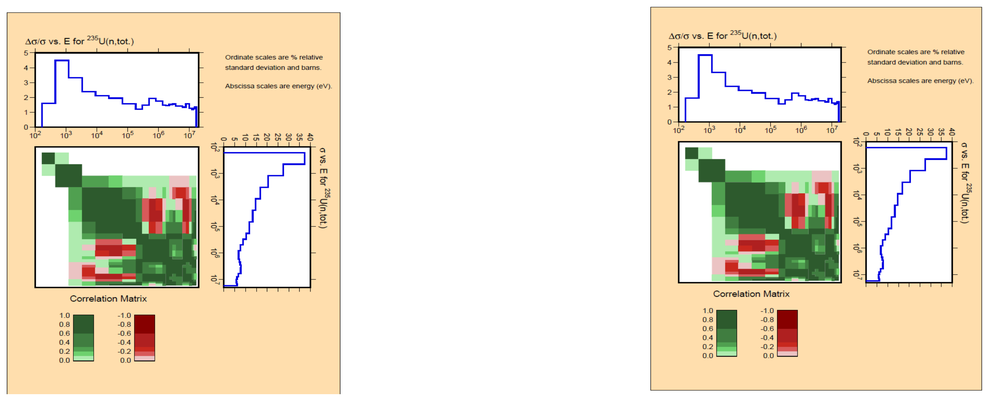

Fig. 2. Comparison of covariance for total to total cross sections (left: ERRORC/RXSP, right: ERRORR/NJOY).

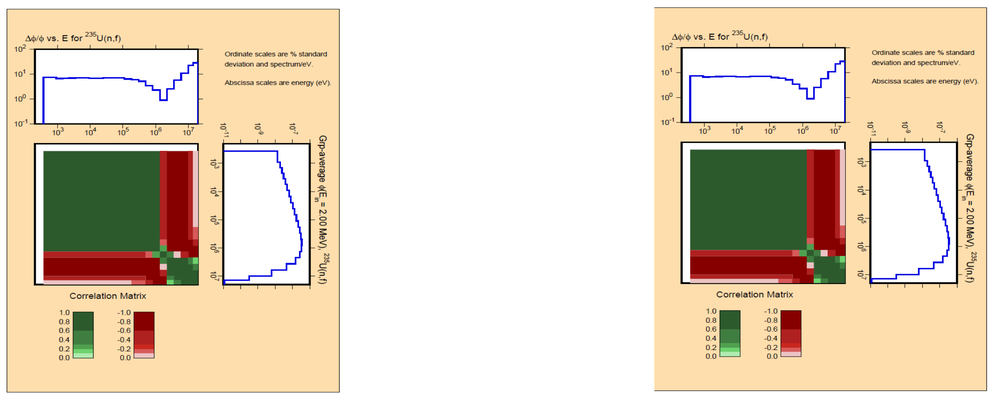

Fig. 3. Comparison of covariance for fission spectrum (left: ERRORC/RXSP, right: ERRORR/NJOY).

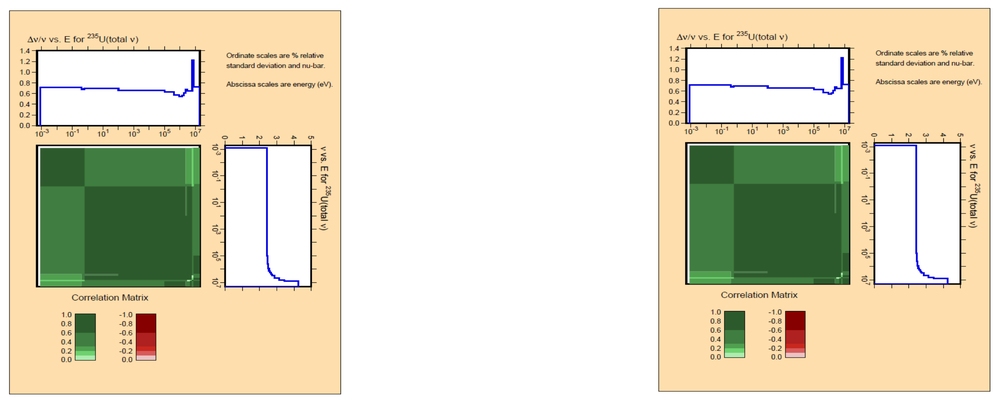

Fig. 4. comparison of covariance nu-bar (left: ERRORC/RXSP, right: ERRORR/NJOY).

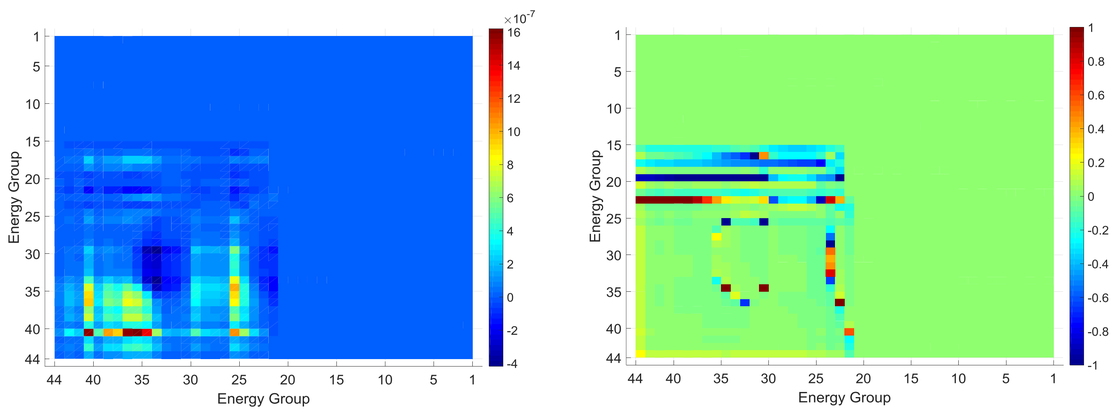

Fig. 5. Covariance contribution from resonance parameters in resolve resonance range for ^{235}U processed by RXSP and NJOY (left: RXSP, right: the relative difference w/ and w/o self-shielding).

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- Conclusions
  - ➢ The ERRORC module has been developed into RXSP code to extend its capability of multi-group covariance matrices processing from point-wise covariance matrix data stored in ENDF
  - ➢ The comparison of microscopic multi-group cross sections covariance matrices of nu-bar, fission spectrum, reaction cross sections for ^{235}U nuclide has been conducted between RXSP and NJOY code to verify its accuracy.
  - ➢ The covariance contribution from resonance parameters in resolve resonance range for 235U has been presented and perform the treatment capability for implicit effect from the uncertainty of resonance parameters

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