Perspective on Advances in Resonance-Region Nuclear Modeling and Opportunities for Future Research

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The advent of high-fidelity radiation-transport modeling capabilities, coupled with the need to analyze complex nuclear systems, has served to emphasize the importance of high-precision cross-section data, including the associated covariance information.

Due to the complex nature of resonance-region interactions, cross-section data cannot be calculated directly from theory; rather, high-precision resonance-region cross-section measurements must be made at facilities such as Oak Ridge Electron Linear Accelerator at the Oak Ridge National Laboratory (ORELA), Geel Electron Linear Accelerator (GELINA), Rensselaer Polytechnic Institute (RPI), etc. In order to extract accurate cross-section data from these measurements, detailed nuclear modeling of the measured data is performed to parameterize the cross-section behavior in the resonance range.

In recent years, resonance-region nuclear-modeling research has led to advances in analysis capabilities for providing resonance-parameter covariance data. Significant effort has been devoted to quantifying uncertainty information in an effort to facilitate the calculation of realistic and accurate resonance-parameter covariance matrices. Both statistical and systematic uncertainties must be included in resonance-parameter uncertainty analyses. Statistical uncertainties arising from measurements contribute only to the diagonal of the covariance matrix; off-diagonal contributions arise from multiple sources (e.g., systematic errors in cross-section measurements, correlation due to the nuclear reaction formalism, etc.). Methods have been developed for efficient, accurate, and easy-to-use treatment of the full off-diagonal data covariance matrices during analyses in the resolved resonance region.

Improved resonance-region formats have been approved for use in the Evaluated Nuclear Data File (ENDF/B) System. The new format for resonance parameters permits reporting of quite general R-matrix analyses, even those involving threshold reactions or charged-particle channels. New formats for the resonance-parameter covariance matrix make it possible to report even very large covariance matrices.

The objective of the full paper will be to highlight advances in resonance-region nuclear modeling with particular emphasis on the covariance analysis capabilities. The paper will discuss areas where future research is needed to further advance the state of the art nuclear modeling capabilities.