NUCLEAR ENERGY UNIVERSITY PROGRAMS

Development of Subspace-Based Hybrid Monte Carlo-Deterministic Algorithms for Reactor Physics Calculations

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Project Number: 09-804

Initiative/Campaign: AFCI/Modeling & Simulation

Abstract

This project will develop a mathematically justified, computationally efficient massively parallelized framework for elucidating the coupling between Monte Carlo and deterministic models in order to achieve the following direct objectives:

- Accelerate the convergence of Monte Carlo calculations via enhanced biasing methods.
- Enhance the accuracy and efficiency of coupled Monte Carlo-deterministic calculations for reactor analysis.
- Determine energy-collapsed cross-sections from Monte Carlo solutions for deterministic methods.
- Accumulate sensitivity coefficients of all responses, e.g., reactor design parameters, reactivity coefficients, detectors responses, flux, and power distributions throughout the core, with respect to all basic input data, e.g., nuclear cross-sections data.
- Estimate all reactor core attribute uncertainties due to basic nuclear data uncertainties.
- Enable a reliable and efficient Monte Carlo inverse analysis.

The overarching objective is to introduce a number of advanced computational algorithms, each having merit as a standalone item, while collectively serving as an advanced analysis framework for Monte Carlo methods. The goal is to move Monte Carlo away from being computationally expensive and toward being a genuinely effective technique with a high level of simulation accuracy, combined with fast execution times and the ability to routinely perform sensitivity, uncertainty, and inverse analyses. Enhancing effectiveness will also benefit the detection and shielding communities.