A High-Fidelity Novel and Fast Multigroup Cross Section Generation Method for Arbitrary Geometry and Spectrum

PI: Farzad Rahnema, Georgia Institute of Technology

Collaborators: Dingkang Zhang – Georgia Institute of Technology; Abderrafi M. Ougouag – Idaho National Laboratory

Program: NEAMS

ABSTRACT:

The objective of the proposed project is to develop a novel, high-fidelity, and fast multigroup microscopic or macroscopic cross section generation method for arbitrary geometry configurations and arbitrary energy spectra. This will be accomplished by developing a response-based high order perturbation method to perform hybrid stochastic-deterministic local transport calculations for generating the multigroup cross sections on-the-fly during whole-core calculations. The method will operate on arbitrary user-defined regions (i.e., mesh, fuel pin, block homogenized, or any other). The new method will have the highest fidelity since continuous phase-space (including energy) treatment is used in the local Monte Carlo pre-computation response generation stage. By treating response functions as high-order local perturbations from a small number of pre-computed reference states, multi-group cross sections are computed on-the-fly at arbitrary local state parameter values (including temperature, material density, etc.). This gives the method formidable speed at the time of whole-core calculation, while retaining the Monte Carlo fidelity from the pre-computation stage. The proposed method will be implemented as independent modules that can be easily embedded into any neutron transport or diffusion code through a simple interface for in-memory coupling; though it can also be used as a standalone cross section generator. The modules developed in this proposed project will provide data in a form that can interface with the associated NEAMS toolkit tools and the NEAMS workbench user interface. This will enable advanced neutronics tools such as the NEAMS toolset to perform high-fidelity multigroup multiphysics steady-state and transient calculations that capture and accurately represent the complex resonance interactions and the core environmental effects that exist in heterogeneous reactors, including advanced reactors. The proposed project consists of the following tasks: (1) development of a response function generator/module for implementation into a chosen continuous-energy Monte Carlo code to pre-compute multigroup reaction rates at a set of selected reference states, (2) development of an on-the-fly deterministic cross section updating module to compute the multigroup cross sections for any regions of interest, (3) development of a high-order perturbation method/module to generate multigroup cross sections at arbitrary states to take into account the multi-physics feedback mechanisms on-the-fly, and (4) development of a set of benchmark problems typical of existing and advanced reactor core and fuel assembly configurations and performing side-by-side comparison with existing multigroup cross section generation methods. Examples of demonstration and application benchmarks include LWRs, HTRs (VHTR, FHR, MSR), and other (e.g., Light Bridge fuel assembly if the specification is made available).