CNEC | Consortium for Nonproliferation Enabling Capabilities

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Project Title

Problem-Dependent ORIGEN Library Compression to Increase Computational Efficiency

Project Objective

Develop a general automated method for problem specific library reduction in Origin to better facilitate incorporation of higher fidelity source term calculations in nuclear codes.

Project Description

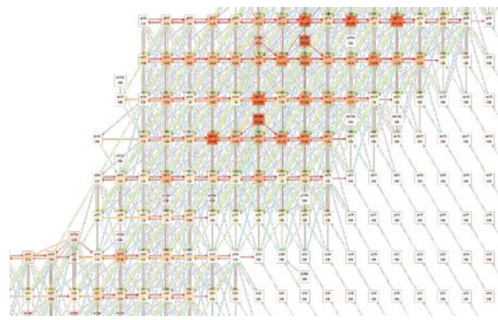
ORIGEN is a highly accurate code to model used fuel isotopic inventory evolution and associated radiation sources. The Oak Ridge Isotope Generation (ORIGEN) code is a depletion model to calculate neutron activation, actinide transmutation, fission product generation, and radiation source terms. This is done through analysis of the full isotopic transition matrix to solve the rate equations that describe the nuclide generation, depletion, and decay processes. This system tracks 2237 isotopes and 54331 transitions, making it the preeminent code for evaluating used nuclear fuel isotopic evolution and production in the world. A next-generation approach to using ORIGEN for accurate source term and depletion models is the direct incorporation of ORIGEN into larger frameworks that rely upon activation and depletion source terms via the modern ORIGEN Application Program Interface (API). However, many problems would benefit most from a reduction in the computational cost of directly performing depletion calculations via ORIGEN.

The method to reduce computational cost relies on a lossy compression algorithm to reduce the ORIGEN reactor data library size. This is achieved by a reduction of the nuclides and transitions being tracked by elimination of nuclides and transitions unimportant for the specified problem, whether that is tracking decay heat, dose, or specific isotopic contents for depletion, resulting in a final library size of approximately 300-500 isotopes. These generated problem-specific libraries do not result in a significant sacrifice in accuracy by focusing on the determination of important contributing nuclides in a generalized manner such to enable reliable calculation of source terms without carrying the full transition matrix through the calculation.

Project Relevance to Nuclear Nonproliferation

The great difficulty in safeguarding the back end of the fuel cycle comes from the variability in the potential content of the used fuel due to many dependencies in initial and reactor operating conditions. To allow for better modeling these variances, accurate source terms need to be calculated. This development is to facilitate the incorporation of Origen for this source term modeling without being computationally costly.

Products and Outcomes of Project



Based on preliminary results with the automated method for creating simplified ORIGEN libraries achieves an order of magnitude reduction in run time by the native ORIGEN API solver. In its current state of development, the automated compression method has been shown to reduce run times by the native ORIGEN CRAM solver from 233ms to 58ms while introducing only 49pcm error to total mass for a single depletion case, showing high accuracy can be achieved with even more significant reductions with certain weighting metrics.

Publications and Reports

S. RICHARDS, B.R. GROGAN., (2017), "Sensitivity Study of INDEPTH for Verification of Facility Spent Nuclear Fuel Declarations". Proc. *International High-Level Radioactive Waste Management Conference*, Charlotte, NC, April, 2017

S. RICHARDS, S.E. SKUTNIK, (2017), "Problem-Dependent ORIGEN Library Compression to Increase Computational Efficiency". Proc. *International Conference on Mathematics and Computational Methods Applied to Nuclear Science and Engineering*, Jeju, Korea, April, 2017

Presentations

S. RICHARDS, B.R. GROGAN., (2017), "Sensitivity Study of INDEPTH for Verification of Facility Spent Nuclear Fuel Declarations". *International High-Level Radioactive Waste Management Conference*, Charlotte, NC, April, 2017

S. RICHARDS, S.E. SKUTNIK, (2017), "Problem-Dependent ORIGEN Library Compression to Increase Computational Efficiency". *International Conference on Mathematics and Computational Methods Applied to Nuclear Science and Engineering*, Jeju, Korea, April, 2017

S. RICHARDS, (2017), "Problem-Dependent ORIGEN Library Compression to Increase Computational Efficiency". University Program Review, San Francisco, CA, June, 2017