INNOVATIONS AND ENHANCEMENTS IN NEUTRONIC ANALYSIS OF THE BIG-10 UNIVERSITY RESEARCH AND TRAINING REACTORS BASED ON THE AGENT CODE SYSTEM

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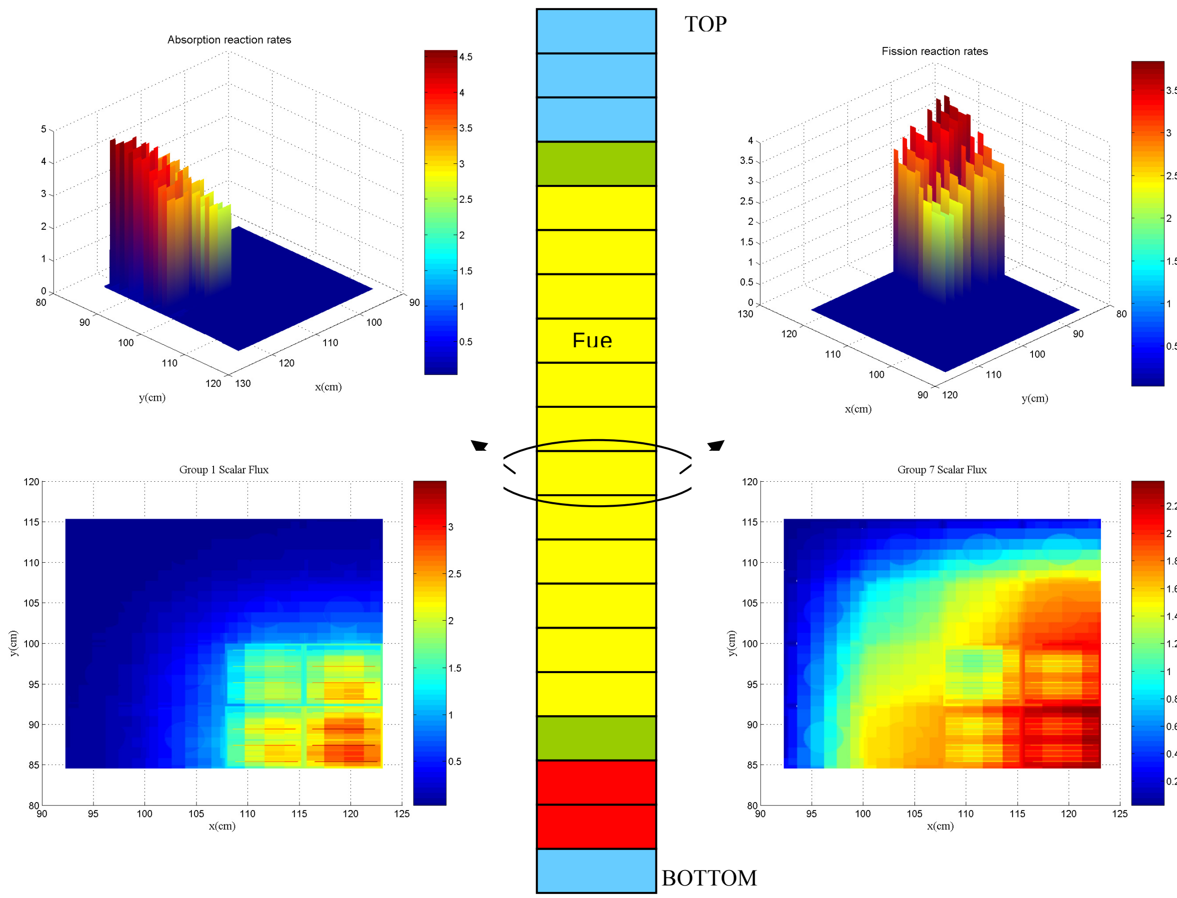
Summary

Introduction. This paper summarizes salient aspects of the "virtual" reactor system developed at Purdue University emphasizing efficient neutronic modeling through AGENT (Arbitrary GEometry Neutron Transport) a deterministic neutron transport code. DOE's Big-10 Innovations in Nuclear Infrastructure and Education (INIE) Consortium was launched in 2002 to enhance scholarship activities pertaining to university research and training reactors (URTRs). Existing and next generation URTRs are powerful campus tools for nuclear engineering as well as a number of disciplines that include, but are not limited to, medicine, biology, material science, and food science. Advancing new computational environments for the analysis and configuration of URTRs is an important Big-10 INIE aim. Specifically, Big-10 INIE has pursued development of a "virtual" reactor, an advanced computational environment to serve as a platform on which to build operations, utilization (research and education), and systemic analysis of URTRs physics. The "virtual" reactor computational system will integrate computational tools addressing the URTR core and near core physics (transport, dynamics, fuel management and fuel configuration); thermal-hydraulics; beam line, in-core and near-core experiments; instrumentation and controls; confinement/containment and security issues. Such integrated computational environment does not currently exist. The "virtual" reactor is designed to allow researchers and educators to configure and analyze their systems to optimize experiments, fuel locations for flux shaping, as well as detector selection and configuration.

Advancement in neutronic analysis of URTRs. The AGENT code is an open architecture multipurpose software package developed for detailed analysis of neutronic aspects of various reactors including arbitrary or less common geometries. It is highly suitable for the URTRs because it preserves all heterogeneities of the atypical fuel assembly arrangements and extremely thin fuel grids. The AGENT methodology represents a synergism of three theories. First, the theory of R-functions used as a mathematical tool to describe the true geometry. Second, R-functions fused with the MOC (Method of Characteristics) applied to the neutron transport Boltzmann equation in two-dimensional (2D) whole core heterogeneous model. Third, one-dimensional (1D) higher-order diffusion correction of 2D MOC, in order to account for full 3D heterogeneous whole core representation. The synergism between the radial 2D transport and the 1D axial transport (to take into account the axial neutron interactions and leakage) is called the 2D/1D method and is employed in DeCART and CHAPLET codes. The unique synergism between the AGENT distinctive geometrical algorithm capable of modeling any current or future reactor core geometry and 3D neutron transport methodology allows for practical, efficient and accurate estimates of the eigenvalues, point-wise flux and reaction rate distributions in any reactor geometry. This paper will describe the basic aspects of the theory and numerical solutions developed for the neutronic analysis of research reactors and will demonstrate the accuracy of the results for the Purdue University research reactor (PUR-1) and for the Ohio State University research Reactor (OSURR). To illustrate the current state of development we show in Figure 1 the AGENT neutron scalar flux distribution and absorption and fission reaction rates for the central plane of the PUR-1 core as well as the accuracy of the eigenvalue compared to other methods. This is a unique and important development. It is the fist time, when we can see all details inside the core and understand all variations in neutron transport.



Effective multiplication coefficient for the PUR-1 core 3D model from different codes

Method	*k*-eff
MCNP 4C (full core)	1.0021 +/-0.0024
DIFF3D (full core)	0.9969
Experiment (full core)	1.0041
AGENT (quarter core)	1.0061

Figure 1. 3D AGENT fine-mesh scalar flux, absorption and fission rate maps for central PUR-1 core plane