Abstract

Advanced Quadrature Selection for Monte Carlo Variance Reduction

by

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Neutral particle radiation transport simulations are critical for radiation shielding and deep penetration applications. Arriving at a solution for a given response of interest can be computationally difficult because of the magnitude of particle attenuation often seen in these shielding problems. Hybrid methods, which aim to synergize the individual favorable aspects of deterministic and stochastic solution methods for solving the steady-state neutron transport equation, are commonly used in radiation shielding applications to achieve statistically meaningful results in a reduced amount of computational time and effort. The current state of the art in hybrid calculations is the Consistent Adjoint-Driven Importance Sampling (CADIS) and Forward-Weighted CADIS (FW-CADIS) methods, which generate Monte Carlo variance reduction parameters based on deterministically-calculated scalar flux solutions. For certain types of radiation shielding problems, however, results produced using these methods suffer from unphysical oscillations in scalar flux solutions that are a product of angular discretization. These aberrations are termed “ray effects”.

The Lagrange Discrete Ordinates (LDO) equations retain the formal structure of the traditional discrete ordinates formulation of the neutron transport equation and mitigate ray effects at high angular resolution. In this work, the LDO equations have been implemented in the Exnihilo parallel neutral particle radiation transport framework, with the deterministic scalar flux solutions passed to the Automated Variance Reduction Generator (ADVANTG) software and the resultant Monte Carlo variance reduction parameters’ efficacy assessed based on results from MCNP5. Studies were conducted in both the CADIS and FW-CADIS contexts, with the LDO equations’ variance reduction parameters seeing their best performance in the FW-CADIS method, especially for photon transport.