Accurate Least-Squares P_N Scaling based on Problem Optical Thickness for solving Neutron Transport Problems

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Abstract

In this paper, we present an accurate and robust scaling operator based on material optical thickness (OT) for the least-squares spherical harmonics (LSP$_N$) method for solving neutron transport problems. LSP$_N$ without proper scaling is known to be erroneous in highly scattering medium, if the optical thickness of the material is large. A previously presented scaling developed by Manteuffel, et al. does improve the accuracy of LSP$_N$ in problems where the material is optically thick. With the method, however, essentially no scaling is applied in optically thin materials, which can lead to an erroneous solution with presence of highly scattering medium. Another scaling approach, called the reciprocal-removal (RR) scaled LSP$_N$, which is equivalent to the self-adjoint angular flux (SAAF) equation, has numerical issues in highly-scattering materials due to a singular weighting. We propose a scaling based on optical thickness that improves the solution in optically thick media while avoiding the singularity in the SAAF formulation.

Keywords: Least Square P$_N$, Neutron Transport Equation, Reactor Shielding, Optical Thickness, Scaling, Thick Diffusion Limit

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