**Toward Whole-Core Neutron Transport Without Spatial Homogenization**

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A long-term goal of computational reactor physics is the deterministic analysis of power reactor core neutronics without incurring significant discretization errors in the energy, spatial or angular variables. In principle, given large enough parallel configurations with unlimited CPU time and memory, this goal could be achieved using existing three-dimensional neutron transport codes. In practice, however, solving the Boltzmann equation for neutrons over the six-dimensional phase space is made intractable by the nature of neutron cross-sections and the complexity and size of power reactor cores. Tens of thousands of energy groups would be required for faithful cross section representation. Likewise, the numerous material interfaces present in power reactor lattices require exceedingly fine spatial mesh structures; these ubiquitous interfaces preclude effective implementation of adaptive grid, meshless methods and related techniques that have been applied so successfully in other areas of engineering science. These challenges notwithstanding, substantial progress continues in the pursuit for more robust deterministic methods for whole-core neutronics analysis. This paper examines the progress over roughly the last decade, emphasizing the space-angle variables and the quest to eliminate errors attributable to spatial homogenization.

As prolog we briefly assess 1990's methods used in light water reactor analysis and review the lessons learned from the C5G7 benchmark exercises which were originated in 1999 to appraise the ability of transport codes to perform core calculations without homogenization. We proceed by examining progress over the last decade much of which falls into three areas. These may be broadly characterized as reduced homogenization, dynamic homogenization and planar-axial synthesis. In the first, homogenization in three-dimensional calculations is reduced from the fuel assembly to the pin-cell level. In the second, iteration between lattice and homogenized calculations yields two-dimensional whole-core results without homogenization error. In the third, planar lattice transport is synthesized with lower-order axial transport to obtain approximate three-dimensional results without planar homogenization. In all three, advances in the method of characteristics play a prominent role, and each rests on some form of equivalence intervention to preserve reaction rates and currents between lattice and homogenized calculations. The talk concludes with some conjectures concerning the potential of interface current, response matrix and related domain decomposition approaches as alternative paths toward achieving whole-core neutronics without homogenization.