Computation of the C5G7 neutron transport benchmark using a spherical harmonics-nodal collocation method

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ABSTRACT

For the analysis of nuclear reactors with complex fuel assemblies in fine mesh applications, the usual approximation of the neutron transport equation by the multigroup neutron diffusion equation does not provide good results. A classical approach to solve the neutron transport equation is to apply the spherical harmonics method to the angular dependence of the equation, obtaining a finite approximation known as the P_L equations. We have developed [1] a nodal collocation method to spatially discretize the multidimensional P_L equations on a rectangular mesh, based on the expansion of the neutronic fluxes in terms of orthonormal Legendre polynomials. In previous works [1] the method was validated for some 2D and 3D neutron transport benchmark problems.

To test the capability of the nodal collocation method to treat advanced reactor problems, in this work we consider the 2D C5G7 MOX Fuel Assembly Benchmark, proposed in [2], for testing the ability of modern deterministic transport methods and codes to treat reactor heterogeneous core problems without spatial homogenisation. Direct whole-core calculations are computationally expensive and require massively parallel computing platforms and vast memory and disk space capabilities. The eigenvalue problem that arises from the application of the nodal collocation method to the C5G7 benchmark problem is numerically solved using SLEPc, a software library [3] for the solution of large scale sparse eigenvalue problems on parallel computers, that is based on the PETSc data structures. We study the convergence of the solution of this problem with the order of the P_L approximation, and also with the Legendre polynomial order. We also analyze the results obtained with different types of spatial meshes.

REFERENCES

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