Solution of the eigenvalue problem and linear systems in the neutron diffusion equation with high performance libraries

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ABSTRACT

Neutron flux distribution inside nuclear reactors is a key factor in nuclear safety. The easiest way to determine it is by solving the neutron diffusion equation. The neutron diffusion equation is a partial differential equation containing temporal and spatial partial derivatives. The spatial distribution can be obtained by using the separation of variables technique for the temporal and spatial terms. Thus, the spatial distribution of the neutron flux is obtained by solving an eigenvalue problem, which only contains spatial derivative terms. The discretization of the spatial derivative terms is performed by discretizing the geometry and using numerical methods. A lot of numerical methods can be applied to the eigenvalue problem of the neutron diffusion equation, such as finite difference, finite element or nodal methods. Once these terms are discretized, a set of matrix equations are obtained, which constitute the eigenvalue problem.

A very effective class of methods for the solution of eigenvalue problems are those based on projection onto a low-dimensional subspace, such as Krylov subspaces. There are several software and libraries containing the algorithm of these methods, which have been widely used. Currently, the state of the art for calculating eigenvalue problems is the SLEPc library. SLEPc, the Scalable Library for Eigenvalue Problem Computations, is a software library for the solution of large, sparse eigenproblems on parallel computers[1]. SLEPc is built on top of PETSc (Portable, Extensible Toolkit for Scientific Computation)[2] and extends it with all the functionality necessary for the solution of eigenvalue problems, which includes matrix operation and solution of linear systems.

In this work, a finite volume method was used for the discretization of the spatial derivtive terms. Then, the SLEPc library was used for the solution of the eigenvalue problem by means of the Krylov-Schur method, which also uses projection methods of PETSc for the calculation of linear systems.

REFERENCES

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