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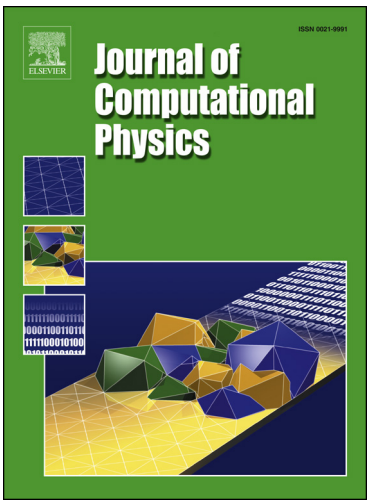

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Stability Analysis of Nonlinear Two-Grid Method for Multigroup Neutron Diffusion Problems

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Abstract

We present theoretical analysis of a nonlinear acceleration method for solving multigroup neutron diffusion problems. This method is formulated with two energy grids that are defined by (i) fine-energy groups structure and (ii) coarse grid with just a single energy group. The coarse-grid equations are derived by averaging of the multigroup diffusion equations over energy. The method uses a nonlinear prolongation operator. We perform stability analysis of iteration algorithms for inhomogeneous (fixed-source) and eigenvalue neutron diffusion problems. To apply Fourier analysis the equations of the method are linearized about solutions of infinite-medium problems. The developed analysis enables us to predict convergence properties of this two-grid method in different types of problems. Numerical results of problems in 2D Cartesian geometry are presented to confirm theoretical predictions.

Keywords: multigroup neutron diffusion equations, iteration methods, eigenvalue problems, Fourier analysis

1. Introduction

The particle transport in matter is described by the linear Boltzmann equation. It is a detailed conservation law in the phase space defined by particle spatial position, its direction of motion and energy. Various approximations to the particle transport equation can be derived by the method of spherical harmonics (P_N method) [1]. This leads to a system of equations for the angular moments of the distribution function. Approximate closures are based on truncation of the expansion of the transport solution. The diffusion model of particle transport is based on the P_1 equations formulated for the zeroth and first moments. The diffusion approximation has some limitations. However, it is a useful tool for design and analysis calculations widely used for simulation of a variety of physical systems [1, 2].

The multigroup diffusion equations for different type of particles are coupled with each other by terms that account for change in energy of particles in scattering. Those are upscattering and downscattering terms. In neutronics problems, fission phenomena also