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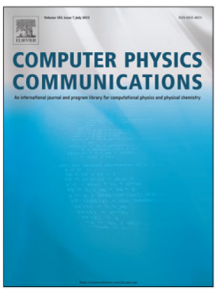

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On the Transfer Matrix of the Modified Power Method

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Abstract

The characteristics of the Transfer Matrix (TM) introduced in the modified power method (MPM) have been studied. Because it can be easily mistaken as the Fission Matrix (FM), the differences between the FM and TM are discussed. Theoretically, it can be concluded that the FM is eigenmode dependent unless a very fine mesh is adopted for the FM tally, whereas the TM is based on the coarse mesh and it can give the correct higher eigenmode solutions if the exact weight cancellation can be done. This is confirmed by comparing the analytical solutions of a one-dimensional monoenergetic homogeneous diffusion problem with the solutions of the 2-by-2 FM and TM. It is further confirmed by the numerical tests that the FM tallied with a coarse mesh cannot give correct higher mode solutions, and the FM tallied with *i*-th mode neutron weights but on a coarse mesh can only give a correct *i*-th mode solution. The numerical tests also confirm that the TM of various sizes, when different numbers of modes are considered, can give the first several eigenmode solutions correctly and consistently with the same fine mesh based weight cancellation. The impact of the mesh size on the results of the MPM has also been investigated. In practice, the FM only requires the fundamental mode neutron source, but the TM requires simulating the first several eigenmode fission sources explicitly. The FM and the TM can be used to accelerate the convergence of the fundamental mode. The FM uses its fundamental eigenvector to adjust the neutron weights. The TM is used to calculate the combination coefficients which can then be used to update the neutron sources. All the comparisons clearly prove that the TM is different from the FM and that the TM requires further investigation.

Keywords: Transfer Matrix, Fission Matrix, Eigenmodes, Modified Power Method

1. Introduction

The Modified Power Method (MPM) has been proposed and studied in recent years [1-18]. It is almost identical to the Fission Matrix (FM) method which has been extensively studied in the past few years [19-26]. The two methods have many applications in common, such as higher eigenmode solutions and acceleration of fission source convergence.

The power method is used by many Monte Carlo transport codes to get the fundamental eigensolution. The error associated with the power method is a combination of eigenmodes. Besides, recent studies reveal that the inter-cycle correlation and the real statistical errors of the Monte Carlo tallies are also related to the higher eigenmodes [27-29]. Therefore, the higher eigenmodes are of interest to reactor physicists who want to investigate details of the fission source convergence issues, or to develop methods to accelerate the fission source convergence. They are also of interest to those who want to evaluate the real statistical errors more effectively.

It should be noted that the higher eigenmodes are of sufficient interests to the neutron transport community. Some Monte Carlo transport codes contain the FM to get the higher modes. The study on MPM shows that it is an alternative way to get the higher modes.