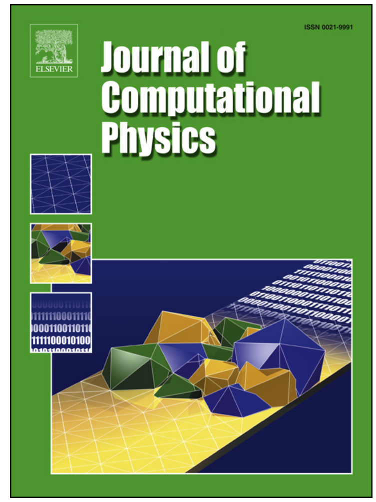

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DEVELOPMENT OF A POINT-KINETIC VERIFICATION SCHEME FOR NUCLEAR REACTOR APPLICATIONS

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ABSTRACT

In this paper, a new method that can be used for checking the proper implementation of time- or frequency-dependent neutron transport models and for verifying their ability to recover some basic reactor physics properties is proposed. This method makes use of the application of a stationary perturbation to the system at a given frequency and extraction of the point-kinetic component of the system response. Even for strongly heterogeneous systems for which an analytical solution does not exist, the point-kinetic component follows, as a function of frequency, a simple analytical form. The comparison between the extracted point-kinetic component and its expected analytical form provides an opportunity to verify and validate neutron transport solvers. The proposed method is tested on two diffusion-based codes, one working in the time domain and the other working in the frequency domain. As long as the applied perturbation has a non-zero reactivity effect, it is demonstrated that the method can be successfully applied to verify and validate time- or frequency-dependent neutron transport solvers. Although the method is demonstrated in the present paper in a diffusion theory framework, higher order neutron transport methods could be verified based on the same principles.

Key Words: computational verification and validation, time-dependent neutron transport, frequency-dependent neutron transport, diffusion theory, neutron fluctuations, neutron noise, point-kinetics

1. INTRODUCTION

The modelling of nuclear power plants relies on complex codes and models capable of resolving the interdependence between several fields of physics. This is particularly true when modelling nuclear reactor cores where a tight coupling between the transport of neutrons, fluid dynamics, and heat transfer exists [1]. The codes used by the nuclear industry, before getting licensed by the safety authorities, must go through a lengthy process of verification and validation. Using common terminology in computer simulations, the verification process aims at verifying the proper implementation of a given mathematical model whereas the validation process targets at demonstrating the correctness of the chosen mathematical model to represent the actual physics [2]-[4].

The verification of computer models is most often performed by comparing the results of the simulations to analytical or semi-analytical solutions [5]-[7]. Being able to obtain analytical or