جامعة عبد المالك السعدي
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Université Abdelmalek Essaadi

Pole for Doctoral Studies
Center for Doctoral Studies Sciences, Technologies, and Medical Sciences

ANNOUNCEMENT OF DOCTORAL THESIS DEFENSE

Centre des Etudes Doctorales Sciences et Techniques et Sciences Médicales

M. SATTI Hicham

Will present here research work with the aim of earning a Doctorate

Doctoral program: Mathematics, Physics, and New Technologies
Discipline: Physics
Specialty: Nuclear Physics

On 04/10/2025 at 17H00 at the Thesis Defense Hall of the Faculty of Sciences of Tetouan, UAE
Under the Theme

Development and verification of OpenNode: a new performant neutronic system based on the nodal expansion method for 2D/3D simulation of multi-group neutron diffusion in nuclear reactor cores

Front of the jury composed of :

First Name & Last Name	Establishment	Designation
Pr. ACHKAR Yamina	FS of Tetouan, UAE	President
Pr. EL MAHJOUB Chakir	FS of Kenitra, UIT	Reviewer
Pr. JAÏ Otman	FST of Fez, USMBA	Reviewer
Pr. BOUKHAL Hamid	FS of Tetouan, UAE	Reviewer
Pr. AZAHRA Mustapha	FS of Tetouan, UAE	Examiner
Pr. EL BARDOUNI Tarek	FS of Tetouan, UAE	Examiner
Pr. EL YOUNOUSSI Chafik	CNESTEN of Rabat	Guest
Pr. EL HAJJAJI Otman	FS of Tetouan, UAE	Supervisor

Research Laboratory: UAE/U01FS Radiation and Nuclear Systems Team - Artificial and Computational Physics Laboratory / Abdelmalek Essaadi University, Faculty of Sciences - Tétouan

Abstract

Nuclear reactor core simulation is essential to ensure safe and efficient reactor operation. Traditional methods such as the Finite Difference Method (FDM) are computationally very expensive for large-scale reactor cores, requiring more efficient approaches. This thesis presents the development, implementation, and verification of OpenNode, a new computational tool based on the nodal method for solving multi-group neutron diffusion equations in 2D and 3D Cartesian geometry. OpenNode is implemented in Fortran 90 for high-performance numerical calculations and features a Python-based graphical user interface (GUI) for enhanced accessibility.

OpenNode relies on the Nodal Expansion Method (NEM) with second and fourth-order polynomial expansions to accurately solve steady-state and transient problems. The method uses the weighted residual method (WRM) and quadratic transverse leakage (QTLA) approximation to handle transverse leakage terms, ensuring a balance between computational efficiency and accuracy. The code supports various calculation modes, including criticality calculations, fixed source problems, and transient simulations, making it a multi-purpose tool for reactor analysis.

The thesis verifies OpenNode across a series of static and transient benchmark problems, including 2D and 3D pressurized water reactors (PWRs), liquid metal fast breeder reactors (LMFBRs), and light water reactors (LWRs). The results demonstrate that OpenNode achieves high accuracy in the calculation of critical parameters such as effective multiplication factor (keff), power distributions, and reactivity feedback, with errors well within acceptable limits. OpenNode's transient analysis capabilities are also validated against the NEACRP and LMW 3D LWR Core Transient Benchmarks, demonstrating its ability to accurately predict power peaks, fuel temperatures, and neutron flux distributions during transient conditions. The integration of thermal feedback significantly improves the accuracy of transient simulations.

OpenNode is not only a powerful tool for reactor analysis, but also a valuable resource for education and training. Its open-source nature encourages collaboration and wider adoption within the nuclear engineering community. The code's ability to simplify complex numerical methods allows researchers and engineers to focus on reactor design, safety assessment, and operational optimization without the need for extensive programming knowledge

Keywords: Power Distribution, Steady-State, Transient Calculation, Thermal feedback, Benchmarks, GUI