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

M. ZAKARIA Mouhssine

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

Doctoral program: Mathematical Sciences, Physics and New Technologies
Discipline: Mathematics
Specialty: Applied Mathematics

On 16/02/2026 at 11H00 at the Thesis Defense Hall, Faculty of Sciences of Tetouan, UAE
Under the Theme

Numerical Approaches for Solving Selected Fractional Differential Equations: Computational Analysis and Algorithms

Front of the jury composed of :

First Name & Last Name	Establishment	Designation
Pr. BOUZELMATE Arij	FS of Tetouan, UAE	President
Pr. EL OMARI M'hamed	FP of Beni Mellal, USMS	Reviewer
Pr. CHABBABI Fadil	FS of Tetouan, UAE	Reviewer
Pr. LAHROUZ Mohamed	FS of Tetouan, UAE	Reviewer
Pr. JARMOUNI Brahim	FS of Tetouan, UAE	Examiner
Pr. HJIAJ Hassane	FS of Tetouan, UAE	Examiner
Pr. MOUJAHID Abdelaziz	FS of Tetouan, UAE	Supervisor

Host Research Structure: Laboratoire de Recherche Analyse Numérique et Analyse Non Linéaire (LaR2A)

Abstract

In this thesis, we explore the study of various fractional differential equations using advanced computational methods, the finite-difference method via the Crank-Nicholson scheme, the spectral element method based on Legendre polynomials, and a weak Galerkin finite-element method. This doctoral research work consists of three distinct parts:

The first part of this work develops finite difference schemes for fractional diffusion equations. A scheme for the Riemann–Liouville space-fractional diffusion equation with a Caputo–Fabrizio time derivative is proposed and shown to be unconditionally stable and convergent through theoretical analysis and MATLAB simulations. A Crank–Nicolson finite difference scheme is then introduced for equations with Riesz space derivatives and Caputo–Fabrizio time derivatives, with unconditional stability and convergence rigorously proved and numerically validated. The second part presents a method of Galerkin spectral elements for a fractional scattering equation, with temporal discretization by the standard formula L_1and spatial discretization via Legendre polynomials.

Unconditional stability is ensured by a variational Galerkin formulation, and an error analysis is performed. MATLAB simulations validate the accuracy and efficiency of the scheme. The final part presents a weak Galerkin finite element method for a reaction-diffusion-convection equation with a fractional time derivative. The Caputo derivative is discretized using the standard formula L_1 on a graded mesh, combined with a weak Galerkin spatial discretization, yielding a fully discrete scheme. Stability and convergence are analyzed, and numerical tests with MATLAB simulations confirm the method's effectiveness.

Keywords: finite difference method, Riesz derivative operator, Caputo-Fabrizio operator, Error estimates, fractional diffusion equation, Caputo derivative, Galerkin spectral element method, Stability, Weak Galerkin finite element method.