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. EL BAKKIOUI Khalid

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

Doctoral program: Engineering Sciences and Techniques
Discipline: Mathematics
Specialty: Applied Mathematics

On 18/07/2025 at 11H00 at the Conference Room of the Faculty of Sciences and Techniques of Tangier, UAE
Under the Theme

Innovative Stochastic Methods in the Study of Dynamical Systems

Front of the jury composed of:

First Name & Last Name	Establishment	Designation
Pr. EL JARROUDI Mustapha	FST of Tangier, UAE	President
Pr. LAHROUZ Aadil	FST of Tangier, UAE	Reviewer
Pr. EL MERZGUIOUI Mhamed	FST of Tangier, UAE	Reviewer
Pr. TRIDANE Abdessamad	Al Ain University, United Arab Emirates	Reviewer
Pr. ABOU EL HANOUNE Younes	ENSA of Al Hoceima, UAE	Examiners
Pr. ERRIANI Mustapha	FST of Tangier, UAE	Examiners
Pr. SETTATI Adel	FST of Tangier, UAE	Supervisor

Research Laboratory: Laboratory of Mathematics and Applications, FSTT, Abdelmalek Essaadi University, Tetouan, Morocco

Abstract

Mathematical models constitute fundamental tools for deciphering the mechanisms of epidemic spread and developing effective control strategies. Their role is crucial because the dynamics of infectious diseases are based on complex interactions between biological, behavioral, and environmental factors. A fine-grained understanding of epidemic processes from their emergence to their resolution is essential to anticipate their evolution and optimize public health interventions.

Historically, this quest for modeling has given rise to a diversity of approaches, ranging from classical deterministic systems to sophisticated stochastic models, including hybrid frameworks and advanced numerical methods. The COVID-19 pandemic, although in a phase of subsidence, has starkly reminded us of the paramount importance of mathematical models in epidemiology. Faced with a virus characterized by heterogeneous transmission, emerging variants, and variable immune responses, traditional approaches revealed their limitations, while models incorporating uncertainty and individual variability proved indispensable. This crisis thus underscored the need to develop more robust theoretical frameworks capable of capturing both global trends and the random fluctuations inherent to epidemic phenomena.

This thesis proposes an in-depth exploration of dynamical systems subject to random perturbations with a central application to the modeling of infectious diseases. Our approach relies on the rigorous analysis of model classes, emphasizing the effects of random noise, whether continuous (Brownian motion, colored noise) or discontinuous (Lévy jumps, Markovian switching). The originality of this work lies in the combination of advanced analytical tools (ergodic theory, Lyapunov inequalities, and stochastic calculus) and high-resolution numerical simulations. The simulations, conducted using Euler-Maruyama methods and adaptive algorithms, validate our theoretical results and illustrate counterintuitive phenomena, such asstochastic persistence in regimes where deterministic models predict extinction.

This work contributes to strengthening the mathematical foundations of stochastic epidemiology while providing operational tools for managing future public health crises.

Keywords: Stochastic SIRS model, Lévy jumps, hybrid switching diffusion, nonlinear incidence rate, persistence, extinction, Lyapunov function, threshold, Markov chains, asymptotic stability, almost sure stability, moment stability.