

MATHEMATICAL MODELLING. THEORY AND APPLICATIONS

# EVOLUTION OF BIOLOGICAL SYSTEMS IN RANDOM MEDIA: LIMIT THEOREMS AND STABILITY

Anatoly Swishchuk and  
Jianhong Wu

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# Evolution Of Systems In Random Media

**Vladimir S. Korolyuk, Anatoly  
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## **Evolution Of Systems In Random Media:**

*Evolution of Systems in Random Media* Vladimir S. Korolyuk, Anatoly V. Swishchuk, 1995-09-11 Evolution of Systems in Random Media is an innovative application oriented text that explores stochastic models of evolutionary stochastic systems in random media Specially designed for researchers and practitioners who do not have a background in random evolutions the book allows non experts to explore the potential information and applications that random evolutions can provide

**Random Motions in Markov and Semi-Markov Random Environments 1** Anatoliy Pogorui, Anatoliy Swishchuk, Ramon M. Rodriguez-Dagnino, 2021-01-12 This book is the first of two volumes on random motions in Markov and semi Markov random environments This first volume focuses on homogenous random motions This volume consists of two parts the first describing the basic concepts and methods that have been developed for random evolutions These methods are the foundational tools used in both volumes and this description includes many results in potential operators Some techniques to find closed form expressions in relevant applications are also presented The second part deals with asymptotic results and presents a variety of applications including random motion with different types of boundaries the reliability of storage systems and solutions of partial differential equations with constant coefficients using commutative algebra techniques It also presents an alternative formulation to the Black Scholes formula in finance fading evolutions and telegraph processes including jump telegraph processes and the estimation of the number of level crossings for telegraph processes

*Particle Systems, Random Media and Large Deviations* Richard Durrett, 1985 Covers the proceedings of the 1984 AMS Summer Research Conference This work provides a summary of results from some of the areas in probability theory interacting particle systems percolation random media bulk properties and hydrodynamics the Ising model and large deviations

*Semi-Markov Random Evolutions* Vladimir S. Korolyuk, Anatoly Swishchuk, 2012-12-06 The evolution of systems in random media is a broad and fruitful field for the applications of different mathematical methods and theories This evolution can be characterized by a semigroup property In the abstract form this property is given by a semigroup of operators in a normed vector Banach space In the practically boundless variety of mathematical models of the evolutionary systems we have chosen the semi Markov random evolutions as an object of our consideration The definition of the evolutions of this type is based on rather simple initial assumptions The random medium is described by the Markov renewal processes or by the semi Markov processes The local characteristics of the system depend on the state of the random medium At the same time the evolution of the system does not affect the medium Hence the semi Markov random evolutions are described by two processes namely by the switching Markov renewal process which describes the changes of the state of the external random medium and by the switched process i.e. by the semigroup of operators describing the evolution of the system in the semi Markov random medium

*Random Evolutions and their Applications* Anatoly Swishchuk, 2000-05-31 This book is devoted to new trends in random evolution and their applications to the stochastic evolutionary system It

contains new developments such as an analogue of Dynkin's formula, boundary value problems, stability and control of random evolutions, stochastic evolutionary equations and driven martingale measures. In addition, it treats statistics of random evolutions, processes, statistics of financial stochastic models and stochastic stability and control of financial markets.

**Audience:** This volume will be of interest to research and applied mathematicians working in the fields of applied probability, stochastic processes and random evolutions, as well as experts in statistics, finance and insurance.

*Stochastic Models of Systems* Vladimir S. Korolyuk, Vladimir V. Korolyuk, 2012-12-06

In this monograph, stochastic models of systems analysis are discussed. It covers many aspects and different stages from the construction of mathematical models of real systems through mathematical analysis of models based on simplification methods to the interpretation of real stochastic systems. The stochastic models described here share the property that their evolutionary aspects develop under the influence of random factors. It has been assumed that the evolution takes place in a random medium, i.e., unilateral interaction between the system and the medium. As only Markovian models of random medium are considered in this book, the stochastic models described here are determined by two processes: a switching process describing the evolution of the systems and a switching process describing the changes of the random medium.

**Audience:** This book will be of interest to postgraduate students and researchers whose work involves probability theory, stochastic processes, mathematical systems theory, ordinary differential equations, operator theory or mathematical modelling and industrial mathematics.

Random Dynamical Systems in Finance Anatoliy Swishchuk, Shafiqul Islam, 2016-04-19

The theory and applications of random dynamical systems (RDS) are at the cutting edge of research in mathematics and economics, particularly in modeling the long-run evolution of economic systems subject to exogenous random shocks. Despite this interest, there are no books available that solely focus on RDS in finance and economics. Exploring this emerging area, *Random Dynamical Systems in Finance* shows how to model RDS in financial applications. Through numerous examples, the book explains how the theory of RDS can describe the asymptotic and qualitative behavior of systems of random and stochastic differential difference equations in terms of stability, invariant manifolds and attractors. The authors present many models of RDS and develop techniques for implementing RDS as approximations to financial models and option pricing formulas. For example, they approximate geometric Markov renewal processes in ergodic, merged, double-averaged diffusion, normal deviation and Poisson cases and apply the obtained results to option pricing formulas. With references at the end of each chapter, this book provides a variety of RDS for approximating financial models, presents numerous option pricing formulas for these models and studies the stability and optimal control of RDS. The book is useful for researchers, academics and graduate students in RDS and mathematical finance, as well as practitioners working in the financial industry.

Discrete-Time Semi-Markov Random Evolutions and Their Applications Nikolaos Limnios, Anatoliy Swishchuk, 2023-07-24

This book extends the theory and applications of random evolutions to semi-Markov random media in discrete time, essentially focusing on semi-Markov chains as switching or driving processes. After

giving the definitions of discrete time semi Markov chains and random evolutions it presents the asymptotic theory in a functional setting including weak convergence results in the series scheme and their extensions in some additional directions including reduced random media controlled processes and optimal stopping Finally applications of discrete time semi Markov random evolutions in epidemiology and financial mathematics are discussed This book will be of interest to researchers and graduate students in applied mathematics and statistics and other disciplines including engineering epidemiology finance and economics who are concerned with stochastic models of systems *Random Light Beams* Olga Korotkova,2017-12-19

*Random Light Beams* Theory and Applications contemplates the potential in harnessing random light This book discusses light matter interactions and concentrates on the various phenomena associated with beam like fields It explores natural and man made light fields and gives an overview of recently introduced families of random light beams It outlines mathematical tools for analysis suggests schemes for realization and discusses possible applications The book introduces the essential concepts needed for a deeper understanding of the subject discusses various classes of deterministic paraxial beams and examines random scalar beams It highlights electromagnetic random beams and matters relating to generation propagation in free space and various media and discusses transmission through optical systems It includes applications that benefit from the use of random beams as well as the interaction of beams with deterministic optical systems Includes detailed mathematical description of different model sources and beams Explores a wide range of man made and natural media for beam interaction Contains more than 100 illustrations on beam behavior Offers information that is based on the scientific results of the last several years Points to general methods for dealing with random beams on the basis of which the readers can do independent research It gives examples of light propagation through the human eye laser resonators and negative phase materials It discusses in detail propagation of random beams in random media the scattering of random beams from collections of scatterers and thin random layers as well as the possible uses for these beams in imaging tomography and smart illumination **Random Motions in Markov and Semi-Markov Random Environments 2** Anatoliy

Pogorui,Anatoliy Swishchuk,Ramon M. Rodriguez-Dagnino,2021-01-11 This book is the second of two volumes on random motions in Markov and semi Markov random environments This second volume focuses on high dimensional random motions This volume consists of two parts The first expands many of the results found in Volume 1 to higher dimensions It presents new results on the random motion of the realistic three dimensional case which has so far been barely mentioned in the literature and deals with the interaction of particles in Markov and semi Markov media which has in contrast been a topic of intense study The second part contains applications of Markov and semi Markov motions in mathematical finance It includes applications of telegraph processes in modeling stock price dynamics and investigates the pricing of variance volatility covariance and correlation swaps with Markov volatility and the same pricing swaps with semi Markov volatilities

Electromagnetic Scattering from Random Media Timothy R. Field,2009 The book develops the dynamical theory of

scattering from random media from first principles Its key findings are to characterize the time evolution of the scattered field in terms of stochastic differential equations and to illustrate this framework in simulation and experimental data analysis The physical models contain all correlation information and higher order statistics which enables radar and laser scattering experiments to be interpreted An emphasis is placed on the statistical character of the instantaneous fluctuations as opposed to ensemble average properties This leads to various means for detection which have important consequences in radar signal processing and statistical optics The book is also significant also because it illustrates how ideas in mathematical finance can be applied to physics problems in which non Gaussian noise processes play an essential role This pioneering book represents a significant advance in this field and should prove valuable to leading edge researchers and practitioners at the postgraduate level and above

*Interacting Stochastic Systems* Jean-Dominique Deuschel, Andreas Greven, 2005-12-05 Core papers emanating from the research network DFG Schwerpunkt Interacting stochastic systems of high complexity

Stochastic Systems in Merging Phase Space Vladimir Semenovich Koroliuk, Nikolaos Limnios, 2005 This book provides recent results on the stochastic approximation of systems by weak convergence techniques General and particular schemes of proofs for average diffusion and Poisson approximations of stochastic systems are presented allowing one to simplify complex systems and obtain numerically tractable models The systems discussed in the book include stochastic additive functionals dynamical systems stochastic integral functionals increment processes and impulsive processes All these systems are switched by Markov and semi Markov processes whose phase space is considered in asymptotic split and merging schemes Most of the results from semi Markov processes are new and presented for the first time in this book

**Markov Random Flights** Alexander D. Kolesnik, 2021-01-04 Markov Random Flights is the first systematic presentation of the theory of Markov random flights in the Euclidean spaces of different dimensions Markov random flights is a stochastic dynamic system subject to the control of an external Poisson process and represented by the stochastic motion of a particle that moves at constant finite speed and changes its direction at random Poisson time instants The initial and each new direction is taken at random according to some probability distribution on the unit sphere Such stochastic motion is the basic model for describing many real finite velocity transport phenomena arising in statistical physics chemistry biology environmental science and financial markets Markov random flights acts as an effective tool for modelling the slow and super slow diffusion processes arising in various fields of science and technology Features Provides the first systematic presentation of the theory of Markov random flights in the Euclidean spaces of different dimensions Suitable for graduate students and specialists and professionals in applied areas Introduces a new unified approach based on the powerful methods of mathematical analysis such as integral transforms generalized hypergeometric and special functions Author Alexander D Kolesnik is a professor Head of Laboratory 2015 2019 and principal researcher since 2020 at the Institute of Mathematics and Computer Science Kishinev Chi in u Moldova He graduated from Moldova State University in 1980 and earned his PhD from the Institute of

Mathematics of the National Academy of Sciences of Ukraine Kiev in 1991 He also earned a PhD Habilitation in mathematics and physics with specialization in stochastic processes probability and statistics conferred by the Specialized Council at the Institute of Mathematics of the National Academy of Sciences of Ukraine and confirmed by the Supreme Attestation Commission of Ukraine in 2010 His research interests include probability and statistics stochastic processes random evolutions stochastic dynamic systems random flights diffusion processes transport processes random walks stochastic processes in random environments partial differential equations in stochastic models statistical physics and wave processes Dr Kolesnik has published more than 70 scientific publications mostly in high standard international journals and a monograph He has also acted as external referee for many outstanding international journals in mathematics and physics being awarded by the Certificate of Outstanding Contribution in Reviewing from the journal Stochastic Processes and their Applications He was the visiting professor and scholarship holder at universities in Italy and Germany and member of the Board of Global Advisors of the International Federation of Nonlinear Analysts IFNA United States of America

**Directed Polymers in Random Environments** Francis Comets, 2017-01-26 Analyzing the phase transition from diffusive to localized behavior in a model of directed polymers in a random environment this volume places particular emphasis on the localization phenomenon The main question is What does the path of a random walk look like if rewards and penalties are spatially randomly distributed This model which provides a simplified version of stretched elastic chains pinned by random impurities has attracted much research activity but it and its relatives still holds many secrets especially in high dimensions It has non gaussian scaling limits and it belongs to the so called KPZ universality class when the space is one dimensional Adopting a Gibbsian approach using general and powerful tools from probability theory the discrete model is studied in full generality Presenting the state of the art from different perspectives and written in the form of a first course on the subject this monograph is aimed at researchers in probability or statistical physics but is also accessible to masters and Ph D students

*Research in Progress*, 1978 Modeling and Inverse Problems in the Presence of Uncertainty H. T. Banks, Shuhua Hu, W. Clayton Thompson, 2014-04-01 Modeling and Inverse Problems in the Presence of Uncertainty collects recent research including the authors own substantial projects on uncertainty propagation and quantification It covers two sources of uncertainty where uncertainty is present primarily due to measurement errors and where uncertainty is present due to the modeling formulation itself After a useful review of relevant probability and statistical concepts the book summarizes mathematical and statistical aspects of inverse problem methodology including ordinary weighted and generalized least squares formulations It then discusses asymptotic theories bootstrapping and issues related to the evaluation of correctness of assumed form of statistical models The authors go on to present methods for evaluating and comparing the validity of appropriateness of a collection of models for describing a given data set including statistically based model selection and comparison techniques They also explore recent results on the estimation of probability distributions when they are

embedded in complex mathematical models and only aggregate not individual data are available In addition they briefly discuss the optimal design of experiments in support of inverse problems for given models The book concludes with a focus on uncertainty in model formulation itself covering the general relationship of differential equations driven by white noise and the ones driven by colored noise in terms of their resulting probability density functions It also deals with questions related to the appropriateness of discrete versus continuum models in transitions from small to large numbers of individuals With many examples throughout addressing problems in physics biology and other areas this book is intended for applied mathematicians interested in deterministic and or stochastic models and their interactions It is also suitable for scientists in biology medicine engineering and physics working on basic modeling and inverse problems uncertainty in modeling propagation of uncertainty and statistical modeling

**Modeling Complexity In Economic And Social Systems** Frank Schweitzer, 2002-12-09 Economics and the social sciences are in fact the hard sciences as Herbert Simon argued because the complexity of the problems dealt with cannot simply be reduced to analytically solvable models or decomposed into separate subprocesses Nevertheless in recent years the emerging interdisciplinary sciences of complexity have provided new methods and tools for tackling these problems ranging from complex data analysis to sophisticated computer simulations In particular advanced methods developed in the natural sciences have recently also been applied to social and economic problems The twenty one chapters of this book reflect this modern development from various modeling perspectives such as agent based models evolutionary game theory reinforcement learning and neural network techniques time series analysis non equilibrium macroscopic dynamics and for a broad range of socio economic applications market dynamics technological evolution spatial dynamics and economic growth decision processes and agent societies They jointly demonstrate a shift of perspective in economics and the social sciences that is allowing a new outlook in this field to emerge

**Nonlinear Optics and Laser Emission through Random Media** Viola Folli, 2012-06-14 Disorder is everywhere inherently present in nature and is commonly believed to be a synonymous with disturbance As a consequence the methodical and customary study of the dynamics of the electromagnetic field both in the linear and nonlinear optical regimes leans to rule out it from the treatment On the other hand nonlinearity enriches the physical disciplines and brings them closer to reality with respect to the linear approximation Nonlinearity allows to stimulate a wide and rich ensemble of optical responses that beautifies the role of matter in the active processes with electromagnetic fields Independently of each other both of these mechanisms foster localization of light What happens when light enlightens their synergistic interaction When pushed together light disorder and nonlinearity make new and intriguing phenomena emerge This text provides a comprehensive investigation of the role of disorder in the nonlinear optical propagation both in transparent media and lasers Eventually disorder promotes and enhances complex nonlinear dynamics opening new perspectives in applied research driven by the processes of localization of the electromagnetic field The first experimental study of laser emission in granular media unveils how randomness

magnifies and largely affect laser matter interactions Viola Folli in her research work touches and deepens the leading milestones of the new science named Complex Photonics

**Capillary Flows in Heterogeneous and Random Porous Media** Rachid Ababou, 2018-11-26 Capillary phenomena occur in both natural and human made systems from equilibria in the presence of solids grains walls metal wires to multiphase flows in heterogeneous and fractured porous media This book composed of two volumes develops fluid mechanics approaches for two immiscible fluids water air or water oil in the presence of solids tubes joints grains porous media Their hydrodynamics are typically dominated by capillarity and viscous dissipation This first volume presents the basic concepts and investigates two phase equilibria before analyzing two phase hydrodynamics in discrete and or statistical systems tubular pores planar joints It then studies flows in heterogeneous and stratified porous media such as soils and rocks based on Darcy's law This analysis includes unsaturated flow Richards equation and two phase flow Muskat equations Overall the two volumes contain basic physical concepts theoretical analyses field investigations and statistical and numerical approaches to capillary driven equilibria and flows in heterogeneous systems

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## **Table of Contents Evolution Of Systems In Random Media**

1. Understanding the eBook Evolution Of Systems In Random Media
  - The Rise of Digital Reading Evolution Of Systems In Random Media
  - Advantages of eBooks Over Traditional Books
2. Identifying Evolution Of Systems In Random Media
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Evolution Of Systems In Random Media
  - User-Friendly Interface
4. Exploring eBook Recommendations from Evolution Of Systems In Random Media
  - Personalized Recommendations
  - Evolution Of Systems In Random Media User Reviews and Ratings
  - Evolution Of Systems In Random Media and Bestseller Lists
5. Accessing Evolution Of Systems In Random Media Free and Paid eBooks
  - Evolution Of Systems In Random Media Public Domain eBooks
  - Evolution Of Systems In Random Media eBook Subscription Services
  - Evolution Of Systems In Random Media Budget-Friendly Options

6. Navigating Evolution Of Systems In Random Media eBook Formats
  - ePub, PDF, MOBI, and More
  - Evolution Of Systems In Random Media Compatibility with Devices
  - Evolution Of Systems In Random Media Enhanced eBook Features
7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Evolution Of Systems In Random Media
  - Highlighting and Note-Taking Evolution Of Systems In Random Media
  - Interactive Elements Evolution Of Systems In Random Media
8. Staying Engaged with Evolution Of Systems In Random Media
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Evolution Of Systems In Random Media
9. Balancing eBooks and Physical Books Evolution Of Systems In Random Media
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Evolution Of Systems In Random Media
10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
11. Cultivating a Reading Routine Evolution Of Systems In Random Media
  - Setting Reading Goals Evolution Of Systems In Random Media
  - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Evolution Of Systems In Random Media
  - Fact-Checking eBook Content of Evolution Of Systems In Random Media
  - Distinguishing Credible Sources
13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
14. Embracing eBook Trends
  - Integration of Multimedia Elements

- Interactive and Gamified eBooks

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