Preface

The Rocky Mountain Mathematics Consortium (RMMC) Summer School "Stochastic equations for complex systems: Theory and applications" took place for two weeks in June, 2014 at the University of Wyoming in Laramie. This summer school involved about 80 graduate students and lecturers from all over the United States and Europe. Mathematical analyses and computational predictions of the behavior of complex systems are needed to effectively deal, for example, with weather and climate predictions, and the optimal design of technical processes. Given the random nature of such systems and the recognized relevance of randomness, the equations used to describe such systems usually need to involve stochastics. The basic goal of this summer school was to introduce graduate students to the mathematics and application of stochastic equations to the modeling of complex systems. One of the known problems of research in this field is that mathematicians, engineers, and physicists generally use rather different terminology to present the results of their analyses. Therefore, a particular goal of this summer school was to create bridges between different analysis methods and techniques in order to contribute to a growing cooperation between researchers in different fields.

Following the lectures of our RMMC Summer School, the book presents eight selected chapters. Each of the chapters addresses questions that are relevant to the mathematical analysis and computational prediction of the behavior of complex systems on the basis of stochastic equations. The first three chapters provide introductions to different topics on mathematical analysis. "An Introduction to the Malliavin Calculus and Its Applications" focuses on the Malliavin calculus with applications to stochastic integral representation, density formulas, smoothness of densities, and normal approximations. "Fractional Brownian Motion and An Application to Fluids" describes fractional Brownian motion with application to vortex dynamics in fluids, and "An Introduction to Large Deviations and Equilibrium Statistical Mechanics for Turbulent Flows" deals with large deviations with applications to the equilibrium statistical mechanics of turbulent flows. "Recent Developments on the Micropolar and Magneto-Micropolar Fluid Systems: Deterministic and Stochastic Perspectives" and "Pathwise Sensitivity Analysis in Transient Regimes" focus on the application of mathematical tools to the analysis of stochastic equations: the analysis of magneto-hydrodynamic equations and the sensitivity analysis of stochastic equations are considered. The development and application of stochastic methods to simulate turbulent flows seen in reality are the concern of "The Langevin Approach: A Simple Stochastic Method for Complex Phenomena," "Monte Carlo Simulations of Turbulent Non-Premixed Combustion Using a Velocity Conditioned Mixing Model," and "Massively Parallel FDF Simulation of Turbulent Reacting Flows." In particular, "The Langevin Approach: A Simple Stochastic Method for Complex Phenomena" explains how observations can be used for the design of stochastic equations. "Monte Carlo Simulations of Turbulent Non-Premixed Combustion Using a Velocity Conditioned Mixing Model" and "Massively Parallel FDF Simulation of Turbulent Reacting Flows" describe the stochastic modeling of turbulent reacting flows using techniques that differ by their predictive capability and computational requirements.

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