mathematics

Editorial

Special Issue: "Transport Phenomena Equations: Modelling and Applications"

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1. Introduction

Transport theory has always been an area of widespread interest. The term "transport" is often applied to the study of phenomena governing the rates of flow of mass, energy and momentum (or fluid flow). The Guest Editors' previous research within this field of study involved modelling and qualitative/quantitative analysis. They were inspired by the enormous potential of transport theory for applications within real phenomena. These phenomena are found in a number of combined processes in various fields, such as chemical, food, biomedical and environmental sciences. This Special Issue focuses on recent advancements in Transport Equations research and its various applications. It provides a great opportunity for disseminating recent results from theoretical and numerical studies from a molecular, microscopic, mesoscopic, or macroscopic point of view across the spectrum of transport phenomena, from scientific inquiries to practical applications.

2. Contributions

This Special Issue contains nine papers, whose 25 authors come from the following countries: Italy, Serbia, Bosnia–Herzegovina, Mexico, Chile, and Russia. The contributions can be grouped according to their field of application:

Medicine: The largest number of contributions relate to modeling in health sciences: specifically, Contribution 1 presents an artificial neural network model to describe the lymph nodes transport function. This approach complements the computational physics-based model of a stationary fluid-flow through the lymph node and the fluid transport across the blood vessel system. It allows for a more realistic description and prediction of immune cell circulation.

Contribution 2 introduces an agent-based model that reproduces the dynamics of two cell populations, i.e., tumor cells and leukocytes, within the framework of cancer-on-chip technology, an immuno-oncology microfluidic chip aimed at studying the fundamental mechanisms of immunocompetent behavior. A simulation tool based on this model is shown to successfully mimic the experimentally observed behavior in a microchip coculture of wild-type leukocytes and treated tumor cells.

Contribution 3 analyzes the dynamics of HIV infection in vivo and the immune system interactions with the virus by studying a two-dimensional HIV diffusion model from a new perspective, in terms of a multi-objective optimization problem. After linearization and discretization, the model is solved by an instantaneous Control Algorithm; the authors show that, despite the adopted simplifications, the model still captures the real dynamics of the infection.

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Contribution 4 considers the transport of synaptic electric impulses as described by a FitzHugh–Rinzel model and finds conditions ensuring the existence of bounded solutions and absorbing sets for the system. The analysis of such models is reflected in a vast number of realistic mathematical models and paves the way for further research into both stability problems and the Hopf bifurcations that are so essential for the study of bursting oscillations.

Contribution 5 proposes a mathematical model to describe drug delivery from polymer coatings on implants; the model considers a unidirectional recursive diffusion process, along with the convective phenomena from the polymer matrix to the liquid where the drug is delivered. Both single drug delivery and recursive delivery scenarios are discussed.

Population Dynamics: Applications to environmental and social sciences are also of great interest. Contribution 6 generalizes a predator–prey model with logistic growth of prey and hunting cooperation of predators by including terms representing the species' movements. The interplay between the aggregated movements of bands of both populations and the individual velocities is characterized by a traveling waves analysis. Theoretical results on the stability of the traveling bands equilibria, and a comparison with a model without advective terms, are obtained and confirmed by numerical simulations.

Contribution 8 considers a nonlinear model for the spread of urban crime based on the prey–predator interaction, incorporating a law enforcement term where the introduction of spatial diffusion can modify the forecasts of the non-spatial counterpart model. Cross-diffusion-induced instability is characterized. The study shows the importance of considering population movement and spatial heterogeneity (which is well known and recognized in many fields at present) in the analysis of social interactions.

Material Sciences: The results of the following contributions are also of great applicative value. Contribution 7 addresses the problem of concrete damage detection through the use of acoustic emission: a localization method for crack detection in a concrete sample based on the time of arrival of the elastic wave generated by the crack formation to a group of sensors positioned on the boundary of the sample is theoretically developed and its validity is numerically assessed.

Contribution 9 develops a model of the laser heating of semiconductors and studies the evolution of recombination heat sources in a laser pulse-illuminated semiconducting sample. The model is based on the non-linear ambipolar diffusion equation describing the photo-generated excess charge carriers, linearized under a low-level injection approximation.

3. Conclusions/Acknowledgments

The Guest Editors would like to thank all the authors for presenting their research results in the Special Issue "Transport Phenomena Equations: Modelling and Applications". Furthermore, we are extremely grateful to all the reviewers for their timely and insightful reports, and to the staff of the Editorial Office for their support in preparing this Special Issue. We hope that this Special Issue will inspire other researchers to carry out new research considering the proposed contributions.

Conflicts of Interest: The authors declare no conflicts of interest.

List of Contributions

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