



Preface

Special issue: Mathematical Modeling with Measures

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The mathematical modeling of natural phenomena by means of equations for functions that represent densities or concentrations has a long-lasting history, meeting substantial success and appreciation. In the past two decades, modeling with measures has gained interest in a growing community. ‘Measures’ are versatile mathematical objects from at least a two-fold perspective: (i) a measure is an effective quantity that can naturally be cast in a balance principle leading to suitable mass, momentum, and energy equations, and (ii) a measure can define mathematically precise relations between discrete, continuum or stochastic objects within a unifying framework. Deterministic measure-valued equations have appeared naturally as large-population limits of stochastic population models in a precise functional analytic sense. For instance, this framework has been used to consider Bayesian parameter estimation problems based on data for the spread of infectious diseases. The progress is taking place rapidly in a diversity of directions, based on a functional-analytic framework that itself is still under development.

This special issue contributes to the field by collecting new results emerging in population dynamics, understood as the evolution of large groups of individuals. Here, the word *individuals* is intended in a very wide sense, including cancer cells as well as vehicles on a highway, pests fought through pesticides or pedestrians forming a crowd. In several of the 11 contributions, the evolution models are formulated directly in terms of measures, while in the others the modeling with measures lies more in the background. At a first sight, the contributions to this issue can be grouped as follows:

- A stochastic modeling point of view is taken by Dawid Czapla, Sander C. Hille, Katarzyna Horbacz, Hanna Wojewodka-Sciazko in *Continuous dependence of an invariant measure on the jump rate of a piecewise-deterministic Markov process* and by Emilio N. M. Cirillo, Matteo Colangeli, Adrian Muntean, T. K. Thoa Thieu in *A lattice model for active-passive pedestrian dynamics: a quest for drafting effects*;

- The role played by data and the inherent uncertainty quantification is discussed by H.T. Banks, John E. Banks, Jared Catenacci, Michele Joyner, John Stark in *Correctly modeling plant-insect-herbivore-pesticide interactions as aggregate data* and by Enrico Bertino, Régis Duvigneau, Paola Goatin in *Uncertainty quantification in a macroscopic traffic flow model calibrated on GPS data*;
- Simone Göttlich and Stephan Knapp in *Modeling random traffic accidents by conservation laws* as well as Francesca Marcellini in *The Riemann problem for a two-phase model for road traffic with fixed or moving constraints* treat realistic car traffic scenarios;
- Optimization perspectives are proposed by Rinaldo M. Colombo and Mauro Garavello in *Optimizing vaccination strategies in an age structured SIR model* and a control-theoretical point of view is suggested by Rinaldo M. Colombo and Elena Rossi in *A modeling framework for biological pest control*;
- Population dynamics modeled with measures are handled by Horst R. Thieme in *Discrete-time population dynamics on the state space of measures*, while approximation/computability aspects of measure-valued evolutions are discussed by Azmy S. Ackleh, Rainey Lyons and Nicolas Saintier in *Finite difference schemes for a structured population model in the space of measures*. On top of this, preliminary steps for an optimization setup in the measures-based framework are done by Azmy S. Ackleh, Nicolas Saintier, and Jakub Skrzeczkowski in *Sensitivity equations for measure-valued solutions to transport equations*.

The above list shows that a variety of results are being developed on the roots of measure valued models. The analytical tools are quite diverse as well as the basic questions addressed, from basic well posedness results in specific models, to control problems, to the development of specialized analytic frameworks.

As it often happens in young research areas, research is driven by specific applications that suggest the development of a variety of new techniques. The present issue aims at fostering the exchange of information among these different research directions, hoping to enrich them all.

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