Preface

This edited book collects ten surveys on modeling, simulation, and applications of active matter by various types of methods spanning from mathematical kinetic theory to nonequilibrium statistical mechanics. The contributions develop a variety of different viewpoints, such as individual-based models, evolutive games, Brownian particles, kinetic theory, and continuum theories, as well as a combination of these, such as kinetic theory and evolutive games or individual-based and continuum models. The authors of each chapter have been selected among the most active mathematicians operating on the aforementioned challenging field. The contents provide a survey of recent results of the various teams and look ahead to research perspectives. Hence, this book is just timely to provide the scientific community with an up-to-date overview of current research conducted by leading experts in this field.

Indeed, this book covers a broad range of applications, such as biological network formation and network theory in the chapters "Continuum Modeling of Biological Network Formation" and "Interaction Network, State Space, and Control in Social Dynamics"; opinion formation and social systems in the chapters "Recent Advances in Opinion Modeling: Control and Social Influence," "Interaction Network, State Space, and Control in Social Dynamics," "Sparse Control of Multiagent Systems," and "A Review on Attractive–Repulsive Hydrodynamics for Consensus in Collective Behavior"; control theory of sparse systems in the chapters "Recent Advances in Opinion Modeling: Control and Social Influence," "Interaction Network, State Space and Control in Social Dynamics," and "Sparse Control of Multiagent Systems"; theory and applications of mean field games in the chapter "Variational Mean Field Games;" population learning in the chapter "Sparse Control of Multiagent Systems"; dynamics of flocking systems in the chapter "Emergent Dynamics of the Cucker–Smale Flocking Model and Its Variants"; vehicular traffic in the chapter "Follow-the-Leader Approximations of Macroscopic Models for Vehicular and Pedestrian Flows"; and stochastic particles and mean field approximation in the chapter "Mean Field Limit for Stochastic Particle Systems."

Different mathematical tools have been used from methods of generalized kinetic theory and statistical dynamics to stochastic evolutive games, mean field games, and stochastic differential systems. Control theory, flocking analysis, and network theory contribute and enrich the application of the aforementioned mathematical tools.

The variety of applications and the interdisciplinary use of different mathematical tools witness the interest of applied mathematicians toward modeling, qualitative analysis, and computing of large systems of active particles viewed as living, hence complex, systems. This new frontier of science offers to applied mathematicians a broad variety of new challenging problems.

The research activity in the field meets an equally productive scientific environment. In particular, we mention the Ki-Net, an NSF Research Network focused on "Kinetic description of emerging challenges in multiscale problems of natural sciences" (www.ki-net.umd.edu). The Ki-Net, through its main three hubs in the University of Maryland, University of Wisconsin, and UT Austin and an interlinked network of 20+ nodes, fosters a series of activities with a main intellectual focus on development, analysis, computation, and application of quantum dynamics, network dynamics, and kinetic models of biological processes. As such, Ki-Net is a primary outlet for presentation of recent activities in the above areas of active matter. Indeed, many of the authors in this special volume were involved in Ki-Net activities. We mention in this context the recent examples of Ki-Net workshops on modeling and control in social dynamics (October 2014), on groups and interactions in data, networks and biology (May 2015), and on collective dynamics in biological and social systems (November 2015). A complete list of activities can be found at www.ki-net.umd.edu/content/activities, and we use this opportunity to acknowledge the NSF support of Ki-Net Grant #1107444 for funding these activities.

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