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Active Particles, Volume 2

Advances in Theory, Models, and Applications

Birkhäuser

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Preface

This edited book, with title “Active Particles, Volume 2 Advances in Theory, Models, and Applications” collects eight surveys on active matter, a follow-up to Volume 1 under the same title. It blends together contributions which indicate the diversity of the subject matter in theory and applications. These contributions discuss different aspects of active matter at different scales of organization, modeled by agent-based, kinetic, and hydrodynamic descriptions. The study of different models involves different mathematical tools—from the analysis of nonlinear partial differential equations, kinetic theory, and statistical and stochastic dynamics to network theory, mean field approximations, control theory, and flocking analysis. Simulations involve particle dynamics and finite-volume methods and spectral and finite-element methods. The content provides surveys of recent results with a look ahead toward research perspectives. Hence, this book is a timely outlet in providing the scientific community with an up-to-date overview of the current research conducted by leading experts in this field.

The book covers a broad range of applications, including *biological network formation and network theory* in Chapters “Kinetic and Moment Models for Cell Motion in Fiber Structures”, “Kinetic Models for Pattern Formation in Animal Aggregations: A Symmetry and Bifurcation Approach”, and “High-Resolution Positivity and Asymptotic Preserving Numerical Methods for Chemotaxis and Related Models”; *social systems* in Chapters “Kinetic Models for Pattern Formation in Animal Aggregations: A Symmetry and Bifurcation Approach”, “Aggregation-Diffusion Equations: Dynamics, Asymptotics, and Singular Limits”, “Control Strategies for the Dynamics of Large Particle Systems”, “Kinetic Equations and Self-organized Band Formations”, and “A Stochastic-Statistical Residential Burglary Model with Finite Size Effects”; *control theory of sparse systems* in Chapter “Kinetic Equations and Self-organized Band Formations”; *dynamics of swarming and flocking systems* in Chapters “Kinetic Models for Pattern Formation in Animal Aggregations: A Symmetry and Bifurcation Approach”, “Kinetic Equations and Self-organized Band Formations”, and “Singular Cucker-Smale Dynamics”; and *stochastic particles and mean field approximation* in Chapters “Control Strategies for the Dynamics of Large Particle Systems", "Singular Cucker-Smale Dynamics", and "A Stochastic-Statistical Residential Burglary Model with Finite Size Effects".

The variety of applications and the interdisciplinary use of different mathematical tools reflect the interest of applied mathematicians in modeling, qualitative analysis, and computing of large systems of active particles, which are viewed as living, hence complex, systems. This new frontier of science offers a range 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 Universities of Maryland, Wisconsin, and UT Austin and an inter-linked network of 20+ nodes, fostered a series of activities with the main intellectual focus on development, analysis, computation, and application of quantum dynamics, network dynamics, and kinetic models of biological processes. As such, Ki-Net was a primary outlet for the presentation of the recent activities in the above areas of active matter. Indeed, many of the authors in this special volume were involved in Ki-Net activities (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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