

Quantum & Kinetic Problems: Modeling, Analysis, Numerics & Applications

*Partially supported by
Centre for Advanced 2D Materials [CA2DM]*

Tutorial 3 on Emergent Phenomena – from Kinetic Models to Social Hydrodynamics
(2 - 3 December and 9 - 13 December 2019)

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University of Ferrara

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Venue:
IMS Auditorium

Admission is free

3 Prince George's Park Singapore 118402
ims.nus.edu.sg

Quantum and Kinetic Problems: Modeling, Analysis, Numerics and Applications

Tutorial 3 on Emergent Phenomena – from Kinetic Models to Social Hydrodynamics

(2 - 3 December and 9 - 13 December 2019)

Venue:
IMS Auditorium, 3 Prince George's Park Singapore 118402

Monday, 02 Dec 2019

Time	Title	Speaker
0915 - 0930	Registration	
0930 - 1030	Tutorial: Cell-cell adhesion micro-and macroscopic models via aggregation-diffusion systems	José Antonio Carrillo Imperial College London, UK
1030 - 1100	Coffee Break	
1100 - 1200	Tutorial: Cell-cell adhesion micro-and macroscopic models via aggregation-diffusion systems	José Antonio Carrillo Imperial College London, UK

Tuesday, 03 Dec 2019

Time	Title	Speaker
0915 - 0930	Registration	
0930 - 1030	Tutorial: Cell-cell adhesion micro-and macroscopic models via aggregation-diffusion systems	José Antonio Carrillo Imperial College London, UK
1030 - 1100	Coffee Break	
1100 - 1200	Tutorial: Cell-cell adhesion micro-and macroscopic models via aggregation-diffusion systems	José Antonio Carrillo Imperial College London, UK

Wednesday, 11 Dec 2019

Time	Title	Speaker
0915 - 0930	Registration	
0930 - 1030	Tutorial: Collective dynamics, kinetics and social hydrodynamics: the emergence of patterns	Eitan Tadmor University of Maryland, USA
1030 - 1100	Coffee Break	
1100 - 1200	Tutorial: Collective dynamics, kinetics and social hydrodynamics: the emergence of patterns	Eitan Tadmor University of Maryland, USA

Thursday, 12 Dec 2019		
Time	Title	Speaker
0915 - 0930	Registration	
0930 - 1030	Tutorial: Collective dynamics, kinetics and social hydrodynamics: the emergence of patterns	Eitan Tadmor University of Maryland, USA
1030 - 1100	Group Photo & Coffee Break	
1100 - 1200	Tutorial: Collective dynamics, kinetics and social hydrodynamics: the emergence of patterns	Eitan Tadmor University of Maryland, USA
Friday, 13 Dec 2019		
Time	Title	Speaker
0915 - 0930	Registration	
0930 - 1030	Tutorial: Uncertainty quantification for kinetic equations and related problems	Lorenzo Pareschi University of Ferrara, Italy
1030 - 1100	Coffee Break	
1100 - 1200	Tutorial: Uncertainty quantification for kinetic equations and related problems	Lorenzo Pareschi University of Ferrara, Italy
1200 - 1330	Lunch Break	
1330 - 1430	Tutorial: Uncertainty quantification for kinetic equations and related problems	Lorenzo Pareschi University of Ferrara, Italy
1430 - 1500	Coffee Break	
1500 - 1600	Tutorial: Uncertainty quantification for kinetic equations and related problems	Lorenzo Pareschi University of Ferrara, Italy

Abstracts

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Uncertainty quantification for kinetic equations and related problems

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Cell-cell adhesion micro-and macroscopic models via aggregation-diffusion systems

JOSÉ ANTONIO CARRILLO

Imperial College London, UK

ABSTRACT

We discuss microscopic and continuum cell-cell adhesion models and their derivation based on the underlying microscopic assumptions. We analyse the behavior of these models at the microscopic level based on the concept of H-stability of the interaction potential. We will derive these macroscopic limits via mean-field assumptions. We propose an improvement on these models leading to sharp fronts and intermingling invasion fronts between different cell type populations. The model is based on basic principles of localized repulsion and nonlocal attraction due to adhesion forces at the microscopic level. The new model is able to capture both qualitatively and quantitatively experiments by Katsunuma et al. (2016) [J. Cell Biol. 212(5), pp. 561–575]. We also review some of the applications of these models in other areas of tissue growth in developmental biology. We will analyse the mathematical properties of the resulting aggregation-diffusion and reaction-diffusion systems based on variational tools. We will discuss the numerical methods used for their simulation in the discussion sessions.

Collective dynamics, kinetics and social hydrodynamics: the emergence of patterns

EITAN TADMOR

University of Maryland, USA

ABSTRACT

The emergence of self-organization in collective dynamics is a cross-disciplinary phenomenon. It arises in ecology – from fish and birds to bacteria and insects; in social dynamics of human interactions – from pedestrian and opinion dynamics to ratings and marketing; and in sensor-based networks – from macro-molecules and traffic to mobile robot networks. Prototype examples include consensus, flocking, cells forming tissues and self-organization of biological organisms, synchronization and the rendezvous of sensor-based systems.

In this four-tutorial lecture series, we focus on addressing mathematical questions that arise in the context of self-organized collective dynamics.

1. We begin with a survey of several classical alignment-based models for systems of collective dynamics. Alignment, attraction and repulsion reflect different types of interactions which govern systems with different rules of social engagements.

We continue with two natural questions that arise in the context of such systems.

2. What is the large time behavior of such systems? The underlying issue is how long-range vs. short-range communication kernels influence the formation of large-scale patterns.
3. What is the mean-field description of dynamics for large crowds? We discuss the kinetics and social hydrodynamics. The underlying issues are regularity and large-time behavior.
4. We discuss the notions of geometric vs. topological neighborhoods and contemporary issues in collective dynamics governed by short-range communication kernels.

Uncertainty quantification for kinetic equations and related problems

LORENZO PARESCHI

University of Ferrara, Italy

ABSTRACT

We overview some recent results in the field of uncertainty quantification for kinetic equations and related problems with random inputs. Uncertainties may be due to various reasons, like lack of knowledge on the microscopic interaction details or incomplete information at the boundaries or on the initial data. These uncertainties contribute to the curse of dimensionality and the development of efficient numerical methods is a challenge. Recent progress on Monte Carlo methods, multi-fidelity methods and stochastic Galerkin particle methods are briefly presented, with comprehensive literature survey.

References

- [1] J.A. Carrillo, L. Pareschi, M. Zanella. Particle based gPC methods for mean-field models of swarming with uncertainty. *Comm. Comp. Phys.* 25, 508-531, 2019.
- [2] G. Dimarco, L. Pareschi. Multi-scale control variate methods for uncertainty quantification in kinetic equations, *J. Comp. Phys.* 388, 63-89, 2019.
- [3] G. Dimarco, L.Pareschi. Multi-scale variance reduction methods based on multiple control variates for kinetic equations with uncertainties. Preprint arXiv:1812.05485, 2018 (to appear on *Multiscale Model. Simul.*).
- [4] S. Jin, H. Lu, L. Pareschi. A high order stochastic asymptotic preserving scheme for chemotaxis kinetic models with random inputs. *Multiscale Model. Simul.* 16 (2018), no. 4, 1884–1915.
- [5] S. Jin, H. Lu, L. Pareschi. Efficient stochastic asymptotic-preserving implicit-explicit methods for transport equations with diffusive scalings and random inputs. *SIAM J. Sci. Comput.* 40 (2018), no. 2, A671–A696.
- [6] S. Jin, L. Pareschi (eds). *Uncertainty Quantification for Hyperbolic and Kinetic Equations*. SEMA SIMAI Springer Series, 14, 2017.
- [7] L. Pareschi. An introduction to uncertainty quantification for kinetic equations and related problems. In *Trails in Kinetic Theory: foundational aspects and numerical methods*. SEMA SIMAI Springer Series, to appear.