Abstracts

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

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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

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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

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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

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