MULTISCALE DYNAMICS OF COMPLEX INTERACTING SYSTEMS: THEORY, MODELING AND APPLICATIONS

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ABSTRACT

Many real-life phenomena involve interactions between different populations of agents. For instance, we can think of the dynamics of gaseous mixtures, governed by their particles colliding microscopically, or the spread of infectious diseases inside a society, occurring as susceptible individuals come into contact with infected ones. Similarly, in biological and ecological contexts, intraspecific and interspecific interactions, alongside environmental factors, shape the system evolution. All these complex interaction processes can be investigated across multiple scales of increasing level of detail.

These scales are commonly referred to as macroscopic, mesoscopic, and microscopic, and are typically modeled using stochastic, partial differential equations with nonlinear and nonlocal terms. Notable examples include the Maxwell-Stefan and SKT systems, describing the evolution of macroscopic observables, the Boltzmann and Fokker-Planck kinetic equations, which provide a mesoscopic description of phenomena, and the Cucker-Smale and Vicsek models, capturing agent-based microscopic interactions.

Understanding the relationship between these descriptions is a challenging problem that requires the development of appropriate mathematical tools to connect their respective solutions and to study their properties. These aspects are essential for establishing mathematical coherence across different modeling approaches and, furthermore, for explaining the nature of complex collective phenomena, such as self-organization and pattern formation, in terms of simple interaction rules between individuals.

Our mini-symposium aims to present recent advances in various aspects of multiscale models for complex systems, focusing on the connections between the three scales of observation. We bring together researchers from diverse areas of the field, intending to foster discussions and provide opportunities to establish new, fruitful collaborations.