PHYSICAL MATH SEMINAR

Adding Drift to Stochastic Reaction-Diffusion Processes: Model Formulation and Macroscopic Limits

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ABSTRACT:

Particle-based stochastic reaction-diffusion processes are widely used in modeling biological systems at mesoscopic length scales. While their basic properties, relation to macroscopic reaction-diffusion PDEs, and numerical approximation methods are now well-established, adding drift to these models introduces significant open questions. Resolving these questions is necessary for accurately modeling physical phenomena like volume exclusion and short-range interactions, which are thought to be critical to the dynamics of various cellular processes.

This talk presents our recent work on particle-based stochastic reaction-drift-diffusion models where drift arises from one- and two-body interactions. We will begin with the physical formulation of these models, demonstrating how satisfying the detailed balance of reaction fluxes at equilibrium constrains reactive interaction functions for reversible reactions. We will then summarize our work proving the rigorous mean-field large-population limit of such particle models, and outline which types of nonlocal reaction-drift-diffusion partial integral differential equations arise as the macroscopic limit. Time permitting, we will discuss work deriving convergent jump process approximations for numerical simulations, effectively generalizing the Reaction-Diffusion Master Equation to a convergent model that includes drift due to one- and two-body potentials.

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2:30 PM – 3:30 PM

MIT Building 2, room 449

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