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Stochastic modelling of reaction-diffusion processes in biology

Many cellular and subcellular biological processes can be described in terms of diffusing and chemically reacting species. Several stochastic simulation algorithms (SSAs) suitable for the modelling of such reaction-diffusion processes have been recently proposed in the literature. In this talk, two commonly used SSAs will be studied. The first SSA is an on-lattice model described by the reaction-diffusion master equation. The second SSA is an off-lattice model based on the simulation of Brownian motion of individual molecules and their reactive collisions. The connections between SSAs and the deterministic models (based on reaction-diffusion PDEs) will be presented. I will consider chemical reactions both at a surface and in the bulk. I will show how the "microscopic" parameters should be chosen to achieve the correct "macroscopic" reaction rate. This choice is found to depend on which SSA is used. I will also present multiscale algorithms which use models with a different level of detail in different parts of the computational domain.