Multiscale approximations for stochastic reaction networks

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Abstract

A reaction network is a chemical system involving multiple reactions and chemical species. The simplest stochastic model for a network treats the system as a continuous time Markov chain whose state is a vector giving the number of molecules of each species present with each reaction modeled as a possible transition for the state. In classical chemistry, systems are so large that stochastic fluctuations are irrelevant and reaction networks are modeled with systems of ordinary differential equations. Interest in modeling chemical reactions within biological cells has led to renewed interest in stochastic models, since the number of molecules involved, at least for some of the species, may be sufficiently small that the deterministic model does not provide a good representation of the behavior of the system. Modeling is further complicated by the fact that some species may be present in much greater abundance than others. In addition, the rate constants may vary over several orders of magnitude. With these two issues in mind, we consider approaches to the approximation of the stochastic models that take the multiscale nature of the system into account.