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Computational singular perturbation analysis of stochastic differential equations systems with stiffness

Computational singular perturbation (CSP) is a useful method for analysis, reduction, and time integration of stiff ordinary differential equation systems. It has found dominant utility, in particular, in chemical reaction systems with a large range of time scales at continuum and deterministic level. On the other hand, CSP is not directly applicable to chemical reaction systems at micro or meso-scale, where stochasticity plays a non- negligible role and thus has to be taken into account. In this work we develop a novel stochastic computational singular perturbation (SCSP) analysis and time integration framework, and associated algorithm, that can be used to not only construct efficiently the numerical solutions to stiff stochastic chemical reaction systems, but also analyze the dynamics of the reduced stochastic reaction systems. The algorithm is illustrated by an application to a benchmark stochastic differential equation model, and numerical experiments are carried out to demonstrate the effectiveness of the construction.