Applications of the stochastic direct simulation method at systems of evolution partial differential equations with strongly nonlinear diffusion part

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We illustrate the applicability of a stochastic scheme based on path simulations of Markov jump processes at systems of nonlinear partial differential equations in two space dimensions, which usually require computationally demanding, specifically adapted, deterministic algorithms. The general principle of the method of lines reduces evolution partial differential equations to semi-discrete approximations consisting of systems of ordinary differential equations. Our approach is to use for this resulting system a stochastic scheme which is essentially a direct simulation of the corresponding infinitesimal dynamics. We consider as test problem the time-dependent radiation-diffusion equation and show that, in the framework of an appropriate implementation, the stochastic scheme can be a real alternative to deterministic solvers, having the advantage of a simple mathematical core. We discuss also the improvement of the convergence order by exploiting further the full path simulation and performing periodically Picard iterations and/or Runge-Kutta steps based on the computed trajectories. This very general basic scheme can be applied at various problems, while the efficiency of the method depends mainly on the implementation part: data structures and sampling algorithms.