Numerical Simulation of Fractional Space Nonlinear Reaction-Diffusion Models

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Abstract

Fractional differential equations have attracted considerable interest because of their ability to model anomalous transport phenomena. Fractional nonlinear reaction-diffusion models have found numerous applications in biology, chemistry, physics and Engineering. Obtaining analytical solutions of fractional nonlinear reaction-diffusion models is difficult, generally numerical methods are used to simulate these models. Numerical methods and error analysis are very important fields in fractional calculus and its application.

In this paper, we consider three fractional space nonlinear reaction-diffusion models, i.e., Model-1: One-dimensional variable order fractional space nonlinear reaction-diffusion model ; Model-2: Two-dimensional fractional Riesz space nonlinear reaction-diffusion model and Model 3: Two-dimensional variable order fractional nonlinear reaction-diffusion model with variable coefficients. An explicit numerical method, implicit numerical method and extrapolation method are proposed for Model 1, respectively. An implicit numerical method and an alternating direction implicit method are proposed for Model-2, respectively. An alternating direction implicit method is also presented for Model 3. The stability and convergence of the these numerical methods are discussed, respectively. Some numerical examples are given to demonstrate the effectiveness of the methods. These methods and techniques can be extended in a straightforward method to simulate practical application problems in biology, chemistry, physics and engineering.