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Construction and analysis of approximate schemes for the evolution equation of fractional order

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The evolution equations modeling many process that appear in physique, ecologies, hydrogeology, finance etc. For example, the mathematical model of the problem to transport any substance in atmosphere, because of the diffusion and advection factors, presents an evolution equation.The classical model of this problem use the derivatives of entire order for unknown function [1]. In recent years many authors use the partial derivatives of fractional order by the space variables to modeling such process.
In this article is considered the same problem with two space variables of the form

$$\frac{\partial \varphi}{\partial t} - d_+(x)\frac{\partial^\alpha \varphi}{\partial_+ x^\alpha} - d_-(x)\frac{\partial^\alpha \varphi}{\partial_- x^\alpha} - d_+(y)\frac{\partial^\alpha \varphi}{\partial_+ y^\alpha} - d_-(y)\frac{\partial^\alpha \varphi}{\partial_- y^\alpha} = f(x,y,t),$$
$$\varphi(x,y,0) = s(x,y), \qquad (1)$$
$$\varphi(x,y,t) = 0 \qquad on \qquad the \qquad \partial D,$$

in the domain $D = [0,a] \times [0,b]$ with the boundary ∂D and the time interval $[0,T]$, where $1 < \alpha \leq 2, 0 < x < a, 0 < y < b, 0 \leq t \leq T, d_+(x) \geq 0, d_-(x) \geq 0$. The left-hand (+) and the right-hand (-) fractional derivatives of order α in (1) are defined by Riemann-Liouville formulas and will be approximated using the Grunwald formulas [2].The first order time derivative is discretized by the central finite differences. The obtained approximate scheme, with some adequate suppositions, verify the conditions of stability and convergence.

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