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ABSTRACTS

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Anomalous transport equations with multi-term fractional time derivatives

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Recently, the issues of mathematical modeling of the processes of anomalous solute transport in porous media have attracted great attention. Equations in fractional order partial derivatives with an additional effect of time lag are, in general, a powerful tool for analyzing the processes of solute transport in porous media [1].

This paper considers the numerical solution of the diffusion equation with multi-term fractional time derivatives in a finite region.

The equation for the solute transport in a porous medium with multi-term time derivatives in the one-dimensional case is written as [2]

$$\frac{\partial^\alpha c}{\partial t^\alpha} + \sum_{s=1}^{n} r_s \frac{\partial_s^\beta c}{\partial t_s^\beta} = D\frac{\partial^\gamma c}{\partial x^\gamma} + f(t,x),$$

where $\alpha, \beta_s, s = 1, ..., n, \gamma$ are the orders of derivatives, $0 < \beta_s < \beta_s - 1 < ... < \beta_1 < \alpha < 1$, c is the volumetric concentration of the substance, D is the diffusion coefficient, r_s are the coefficients, $f(t,x)$ is the power of the sources of substances, t time, x coordinate. The orders of fractional derivatives α and γ vary in the following range: $0 < \alpha \leq 1, 1 \leq \gamma \leq 2$ and they are understood in the approach of Caputo. In (2) c is a dimensionless quantity and $[\frac{\partial^\alpha c}{\partial t^\alpha}] = T^{-\alpha}$, $[r_s] = T^{\beta_s - \alpha}$, $[D] = \frac{L^\gamma}{T^\alpha}$, $[f(t,x)] = T^{-\alpha}$, L is the dimension of length, T is the dimension of time.

An analysis of the obtained results shows that the use of differential equations with polynomial fractional time derivatives for modeling anomalous diffusion processes allows describe the effects of delayed development of concentration profiles. Taking into account the multi-term nature of the diffusion equation in comparison with the one-term equation leads to a slow spread of the solute concentration in the medium. It is shown that an increase in the value of constant coefficients (r_1, r_2,...,r_s) with local fractional time derivatives, it enhances the process of slowing down the distribution of concentration profiles. A similar enhancement of the retarded effects is also caused by a decrease in the orders of these local time derivatives.

References

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