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A generalized time-fractional convection problem with variable coefficients

Applying the inverse operator method and the multivariate Mittag-Leffler function, we derive a unique analytic solution to the following multi-term time-fractional convection problem on a new space with variable coefficients and $0 < \rho_1 < \rho_2 \cdots < \rho_m < \rho \leq 1$, for the first time, in the Caputo fractional derivative sense:

$$\begin{cases} \frac{{}_c\partial^{\rho}}{\partial t^{\rho}} M(t,\sigma) + \sum_{i=1}^{m} \beta_i \, \frac{{}_c\partial^{\rho_j}}{\partial t^{\rho_j}} M(t,\sigma) + \sum_{j=1}^{n} \lambda_j(\sigma_j) \frac{\partial}{\partial \sigma_j} M(t,\sigma) \\ = f_1(t,\sigma), \quad (t,\sigma) \in [0,1] \times [0,1]^n, \\ M(0,\sigma) = f_2(\sigma). \end{cases}$$

We further present several examples demonstrating power and simplicity of our main results and show that they can be reduced to the classical integral convolution solutions by Green's functions.