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Fast solution methods for space-fractional diffusion equations

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Abstract

We develop fast solution methods for a shifted Grünwald finite difference method for steady-state and time-dependent space-fractional diffusion equations. These methods reduce the memory requirement of the finite difference scheme from $O(N^2)$ to $O(N)$ and the computational complexity from $O(N^3)$ to $O(N \log^2 N)$. Preliminary numerical example runs show the utility of these methods over the traditional direct solvers of the finite difference methods, in terms of computational cost and memory requirements.

Keywords: Fractional diffusion equation, Toeplitz matrix, Levinson method, Superfast method, Fast Fourier transform

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