

# Accepted Manuscript

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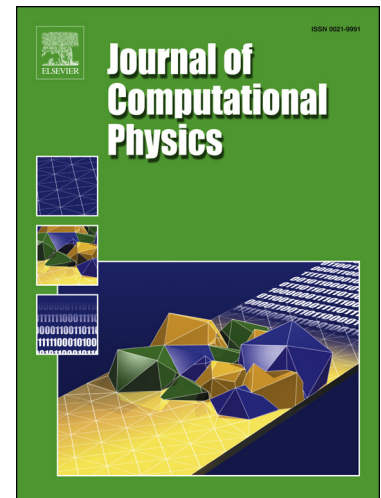
PII: S0021-9991(16)30158-9  
DOI: <http://dx.doi.org/10.1016/j.jcp.2016.05.021>  
Reference: YJCPH 6618

To appear in: *Journal of Computational Physics*

Received date: 31 October 2014  
Revised date: 6 February 2016  
Accepted date: 9 May 2016

Please cite this article in press as: Z. Zhao et al., Preconditioned iterative methods for space-time fractional advection-diffusion equations, *J. Comput. Phys.* (2016), <http://dx.doi.org/10.1016/j.jcp.2016.05.021>

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# Preconditioned iterative methods for space-time fractional advection-diffusion equations

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## Abstract

In this paper, we propose practical numerical methods for solving a class of initial-boundary value problems of space-time fractional advection-diffusion equations. First, we propose an implicit method based on two-sided Grünwald formulae and discuss its stability and consistency. Then, we develop the preconditioned generalized minimal residual (preconditioned GMRES) method and preconditioned conjugate gradient normal residual (preconditioned CGNR) method with easily constructed preconditioners. Importantly, because resulting systems are Toeplitz-like, fast Fourier transform can be applied to significantly reduce the computational cost. We perform numerical experiments to demonstrate the efficiency of our preconditioners, even in cases with variable coefficients.

*Keywords:* Fractional diffusion equations; Toeplitz matrix; Preconditioner; Fast Fourier transform; Conjugate gradient normal residual method; Generalized minimal residual method.

*2000 MSC:* 65F15, 65H18, 15A51.

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## 1. Introduction

In this study, we develop numerical approaches for solving the initial-boundary value problem of a space-time fractional advection-diffusion equation (STFDE) [1]:

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<sup>1</sup>The second author was supported by the research grant MYRG098(Y3-L3)-FST13-JXQ from the University of Macau.

<sup>2</sup>The third author was supported by the Ministry of Science and Technology of Taiwan under grant 104-2115-M-194-006-MY3.

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