Optimal preconditioners for Fractional Differential Equations

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Abstract

Fractional partial order diffusion equations are used to describe diffusion phenomena, that cannot be appropriately modeled by the well known second order diffusion equations.We mention that Fractional Differential Equations (FDEs) are of numerical interest, since there exist only few cases in which the analytic solution is known. Using the implicit Euler formula and the shifted Grünwald formula, we lead to a linear system whose coefficient matrix has a Toeplitz like structure. Taking into account the spectral analysis of such kind of matrices ([1]), we propose a preconditioner for Krylov methods, that under some suitable assumptions performs superlinear convergence for such kind of systems. In addition we extend the idea of such a construction to cover the multidimensional case, i.e Fractional PDE's. A number of numerical examples show the effectiveness of the proposed preconditioners.

References

[1] M. Donatelli, M.Mazza, S. Serra-Capizzano. *Spectral analysis and structure preserving preconditioners for fractional diffusion equations.* Journal of Computational Physics, 307 (2016) 262-279.