Efficient computation of solutions of time-fractional diffusion-reaction equations

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Numerically solving time-fractional diffusion-reaction equations usually poses some not negligible challenges. Since derivatives of fractional order are non-local operators, their numerical treatment involves a persistent memory and, consequently, it is demanded a possible huge need for storage memory and computational resources.
On the basis of the recent work [1], we discuss a strategy to perform numerical simulations in an efficient way, namely by requiring a reasonable occupation of memory and an acceptable CPU time. This strategy is obtained by coupling an ImEx product-integration rule with a kernel compression scheme, a technique allowing the approximation of a non-local problem by a sequence of local problems.
The computational task required by the solution of a possible large number of linear systems of large size is further optimized by reformulating the difference scheme for the space operator in a matrix formulation (according to an approach recently proposed in [2]), so as to require the solution of Sylvester equations only with small matrices.
The accuracy of the proposed scheme is theoretically studied and validated by means of some numerical experiments and the efficiency of this strategy from the computational point of view is also verified.

References

[1] R. Garrappa, M. Popolizio, *A computationally efficient strategy for time-fractional diffusion-reaction equations*, Computers & Mathematics with Applications, 2021.

[2] M.C. D'Autilia, I. Sgura, V. Simoncini, *Matrix-oriented discretization methods for reaction-diffusion PDEs: comparisons and applications*, Computers & Mathematics with Applications, 2020