Computational approach via half-sweep and preconditioned aor for fractional diffusion

ABSTRACT

Solving time-fractional diffusion equation using a numerical method has become a research trend nowadays since analytical approaches are quite limited. There is increasing usage of the finite difference method, but the efficiency of the scheme still needs to be explored. A half-sweep finite difference scheme is well-known as a computational complexity reduction approach. Therefore, the present paper applied an unconditionally stable half-sweep finite difference scheme to solve the time-fractional diffusion equation in a one-dimensional model. Throughout this paper, a Caputo fractional operator is used to substitute the time-fractional derivative term approximately. Then, the stability of the difference scheme combining the half-sweep finite difference for spatial discretization and Caputo time-fractional derivative is analyzed for its compatibility. From the formulated half-sweep Caputo approximation to the time-fractional diffusion equation, a linear system corresponds to the equation contains a large and sparse coefficient matrix that needs to be solved efficiently. We construct a preconditioned matrix based on the first matrix and develop a preconditioned accelerated over relaxation (PAOR) algorithm to achieve a high convergence solution. The convergence of the developed method is analyzed. Finally, some numerical experiments from our research are given to illustrate the efficiency of our computational approach to solve the proposed problems of time-fractional diffusion. The combination of a half-sweep finite difference scheme and PAOR algorithm can be a good alternative computational approach to solve the time-fractional diffusion equation-based mathematical physics model.