A numerical comparison for recent modifications of Adomian decomposition methods for nonlinear fractional KdV equations

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Abstract: The explicit solutions to the modified fractional Korteweg–de Vries (KdV) equation with initial condition are calculated by using the recent modified decomposition methods. To illustrate the application of these methods, numerical results are obtained and compared with classical and modified fractional KdV equations. The numerical results demonstrate that the many of them are relatively accurate and easily implemented.

In the recent years, remarkable progress has been made in the construction of the approximate solutions for nonlinear fractional partial differential equations (nfPDE) [1-7]. In some sense fractional differential equations could represent various real-life problems. Because of this usefulness finding the exact and numerical solutions' methods for these types of equations has become very important. The studies in finding exact solutions to nfPDE, when they exist, are very important for the understanding of most fractional nonlinear physical phenomena.

In this part, we will introduce the reader to a certain nonlinear partial differential equation (PDE) which is characterized by the solitary wave solutions of the classical nonlinear equations that lead to solitons [8-12]. We meant with the classical nonlinear equations of interest usually admit for the existence of a special type of the traveling wave solutions which are either solitary waves or solitons. In this study, we will implement various versions of ADM [13-22] for a few solutions arising from the semi-analytic work of the fractional Korteweg-de Vries (fKdV) equation and modified fractional Korteweg-de Vries (mfKdV) equation for a comparable way.

Keywords: Adomian decomposition method, the Rach–Adomian–Meyers modified decomposition method, Waxwaz's modified decomposition method, fractional mKdV, the solitary wave solutions, modified Riemann–Liouville derivative.

References:

[1] K.S. Miller and B. Ross, An Introduction to the Fractional Calculus and Fractional Differential Equations, Wiley, New York, 1993.

[2] A.A. Kilbas, H.M. Srivastava, and J.J. Trujillo, Theory and Applications of Fractional Differential Equations, Elsevier, San Diego, 2006.

[3] I. Podlubny, Fractional Differential Equations, Academic Press, San Diego, 1999.

[4] G. Jumarie, Modified Riemann-Liouville derivative and fractional Taylor series of nondifferentiable functions further results, Comput. Math. Appl. 51, pp. 1367–1376, 2006.
[5] G. Jumarie, Lagrange characteristic method for solving a class of nonlinear partial differential equations of fractional order, Appl. Math. Lett. 19, pp. 873–880, 2006.
[6] G. Jumarie, Table of some basic fractional calculus formulae derived from a modified Riemann-Liouville derivative for non-differentiable functions, Appl. Math. Lett. 22, pp. 378–385, 2009.
[7] D. Kaya and S. Duran, Some Wave Solutions for Fractional Nonlinear Differential Equations using an Extended Bernoulli Equation as a New Expansion Method, summited for publication.
[8] G.B. Whitham, Linear and Nonlinear Waves, John Wiley and Sons, California, 1974.
[9] P.G. Drazin and R.S. Johnson, Solutions: An Introduction, Cambridge Univ. Press, Cambridge, 1989.
[10] A.M. Wazwaz, Partial Differential Equations: Methods and Applications, Balkema, Rotterdam, 2002.
[11] A.M. Wazwaz, Partial Differential Equations and Solitary Waves Theory, Springer, New York, 2009.
[12] A.M. Wazwaz, Linear and Nonlinear Integral Equations: Methods and Applications, Higher Education, Beijing, Springer, Berlin, 2011.
[13] G. Adomian, Solving Frontier Problems of Physics: The decomposition method, Kluwer Academic Publishers, Boston, (1994.
[14] R. Rach, G. Adomian, R.E. Meyers, A modified decomposition, Comput. Math. Appl. 23, pp. 17–23, 1992.
[15] A.M. Wazwaz, A reliable modification of Adomian decomposition method, Appl. Math. Comput. 102, pp. 77–86, 1999.
[16] A.M. Wazwaz and S. M. El-Sayed, A New Modification of the Adomian Decomposition Method for Linear and Nonlinear Operators, Appl. Math. Comput. 102, pp. 393-405, 2001.
[17] D. Kaya, A Numerical Solution of the Sine-Gordon Equation Using the Modified Decomposition Method, Appl. Math. Comp. 143, pp. 309-317, 2003.
[18] J.-S. Duan, T. Chaolu and R. Rach, Solutions of the initial value problem for nonlinear fractional ordinary differential equations by the Rach–Adomian–Meyers modified decomposition method, Appl. Math. Comput. 218, pp. 8370–8392, 2012.
[19] S. Momani, explicit and numerical solutions of the fractional KdV equation, Appl. Math. Comput. 70, pp. 110–118, 2005.
[20] D. Kaya and I.E. Inan, A Convergence Analysis of the ADM and an Application, Appl. Math. Comp. 161, pp. 1015-1025, 2005.

[21] S.S. Ray and R.K. Bera, An approximate solution of a nonlinear fractional differential equation by Adomian decomposition method, Appl. Math. Comput. 167, pp. 561–571, 2005.
[22] S.S. Ray and R.K. Bera, Analytical solution of a fractional diffusion equation by Adomian decomposition method, Appl. Math. Comput. 174, pp. 329–336, 2006.