Application of Fractional Residual Power Series Algorithm to Solve Newell–Whitehead–Segel Equation of Fractional Order

Abstract: The Newell–Whitehead–Segel equation is one of the most nonlinear amplitude equations that plays a significant role in the modeling of various physical phenomena arising in fluid mechanics, solid-state physics, optics, plasma physics, dispersion, and convection system. In this analysis, a recent numeric-analytic technique, called the fractional residual power series (FRPS) approach, was successfully employed in obtaining effective approximate solutions to the Newell–Whitehead–Segel equation of the fractional sense. The proposed algorithm relies on a generalized classical power series under the Caputo sense and the concept of an error function that systematically produces an analytical solution in a convergent fractional power series form with accurately computable structures, without the need for any unphysical restrictive assumptions. Meanwhile, two illustrative applications are included to show the efficiency, reliability, and performance of the proposed technique. Plotted and numerical results indicated the compatibility between the exact and approximate solution obtained by the proposed technique. Furthermore, the solution behavior indicates that increasing the fractional parameter changes the nature of the solution with a smooth sense symmetrical to the integer-order state.

Keywords: fractional Newell–Whitehead–Segel model; Caputo fractional derivative; fractional residual power series algorithm; multiple fractional power series.

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